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Technical Memorandum

Date:	14 July 2010
To:	Jack Howard, Engineering Manager, Jacobs Engineering
From:	Jesus Sanchez, Geosyntec Consultants Joseph Sura, Geosyntec Consultants Ganesh Krishnan, P.E., CPESC, Geosyntec Consultants Neil Davies, P.E., Geosyntec Consultants
Subject:	Integrity Evaluation of Dike 2 for Extreme Rainfall Events Tennessee Valley Authority (TVA), Kingston Fossil Plant

PURPOSE & BACKGROUND

The purpose of this memorandum is to present the results of the Integrity Evaluation of Dike 2 for Extreme Rainfall Events which was conducted by Geosyntec Consultants (Geosyntec). Dike 2 is located at Tennessee Valley Authority's (TVA) Kingston Fossil Plant. Dike 2 was constructed to detain surface water runoff from the extent of the failed dredge cell areas (ash area) west of the location of the dike. For the purposes of this evaluation, Extreme Rainfall Events are defined as the calculated runoff conditions arising from the 100-, 500-, and 1,000-year 24-hour design storm events.

OVERALL APPROACH & ASSUMPTIONS

The evaluation was conducted in two steps. The first step involved a hydrologic analysis. The purpose of the hydrologic analysis was to calculate the peak impounded water level behind Dike 2 arising from the above-described extreme rainfall events. The second step involved a geotechnical integrity evaluation. The purpose of the geotechnical integrity evaluation was to calculate the factor of safety against static and seismic slope stability failure of Dike 2.

In conducting the above evaluation, it was assumed that the impoundment behind Dike 2 was filled with ash to the top of the overflow risers. It was also assumed that the tail water condition

for discharge to the Emory River was at the summer pool elevation (i.e., Elevation 741 feet-MSL).

ANALYSES

Hydrologic Analysis

The purpose of the hydrologic analysis was to calculate the peak impounded water level behind Dike 2 arising from the previously-described extreme rainfall events. The analysis was conducted using accepted hydrologic modeling procedures, and utilized methodology prescribed in Soil Conservation Service (SCS) Technical Release 55 (SCS, 1986). The analysis was conducted by developing a computer model of the contributing watersheds using the software package HydroCAD™ (HydroCAD, 2009).

Prior to conducting the analysis, Geosyntec conducted a site visit on 30 June 2010. The hydrologic analysis considered the scenario where the surface water runoff from the ash areas (approximately 170 acres) and the surrounding watershed (approximately 2,560 acres) would exceed the capacity of surface water conveyance features upstream of Dike 2. Therefore, detailed modeling of flow through conveyance features upstream of Dike 2 was not performed in the hydrologic analysis. Instead a fictitious modeling scenario was considered, where the flooded area below the top of Dike 2 is considered to be the effective volume of water that is impounded by the dike.

Using the above approach, the water elevations behind Dike 2 for the 100-, 500-, and 1,000-year 24-hour design storm events were calculated. Detailed analyses are provided in Appendix A of this memorandum.

Geotechnical Integrity Evaluation

The purpose of the geotechnical integrity evaluation was to calculate the factor of safety against static and seismic slope stability failure of Dike 2. The analysis considered a single cross-section through the emergency spillway. The material properties and subsurface conditions were based on previous work and calculations performed on the Dike 2 area (Geosyntec, 2009). The static and seismic slope stability analyses were conducted using computer program SLIDE (Rocscience, 2010). The stability analyses considered four different scenarios of water levels behind Dike 2 as indicated below.

- 744.5 feet-MSL – Lower than the crest of the emergency spillway.

- 746.0 feet MSL – Crest of the emergency spillway.
- 748.0 feet MSL – Approximately half available flow depth in the emergency spillway.
- 750.0 feet MSL – Top of the embankment of Dike 2.

Detailed analyses are provided in Appendix B of this memorandum.

RESULTS & CONCULSIONS

Table 1 below summarizes the results of the hydrologic analysis for the various extreme rainfall events which were considered. As shown on Table 1 the calculated water level is below the crest of the emergency spillway for the 100-year and the 500-year design storm events. The analysis indicates that during the 1,000-year event, approximately 0.6 feet of flow depth may be expected in the emergency spillway.

Table 1. Summary of Hydrologic Analysis

Return Period (years)	Rainfall Depth (inches)	Calculated Water Level (feet-MSL)	Comment
100	6.77	744.3	Calculated water level is below the emergency spillway elevation.
500	8.31	745.8	Calculated water level is below the emergency spillway elevation.
1,000	9.00	746.6	Calculated water level is 0.6 feet above the crest of the emergency spillway.

Table 2 below summarizes the results of the geotechnical integrity evaluation for four water elevation scenarios which were considered. The calculated minimum factor of safety value for static slope stability was 1.6 for the four water elevation scenarios, which is greater than the target factor of safety of 1.5. For the seismic slope stability analyses, the calculated permanent seismic deformation was 1.6 inches, which does not exceed the 6 to 12 inches of maximum allowable deformation (Seed and Bonaparte, 1992).

Table 2. Summary of Geotechnical Integrity Evaluation

Water Elevation in Geotechnical Analysis (feet-MSL)	Calculated Static Factor of Safety (FS)	Calculated Permanent Seismic Deformation (inches)	Comment
744.5	1.61	1.6	Water level 744.5 feet-MSL is greater than the calculated water level from the 100-year, 24-hour design storm event.
746	1.61	1.6	Water level 746 feet-MSL is greater than the calculated water level from the 500-year, 24-hour design storm event.
748	1.61	1.6	Water level 748 feet-MSL is greater than the calculated water level from the 1,000-year, 24-hour design storm event.
750	1.61	1.6	Water level 750 feet-MSL is greater than the calculated water level from the 1,000-year, 24-hour design storm event.

As noted in Table 2 above, the results of the geotechnical integrity analysis for static and seismic conditions are acceptable for water elevations exceeding the 1,000-year design storm event. However, for the 1,000-year storm event, flow can be expected in the emergency spillway, and it is likely that localized erosion may occur in the downward face of the dike, and that minor repairs may be required after the storm event.

REFERENCES

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Spencer, E., *"The Thrust Line Criterion in Embankment Stability Analysis"*, Géotechnique, Vol. 23, No. 1, pp. 85-100, 1973.

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* * * * *

APPENDIX – A

HYDROLOGIC ANALYSIS

Geosyntec
consultants

COMPUTATION COVER SHEET

Client: TVA **Project:** Integrity Evaluation of Dike 2 **Project #:** GK4693 **Task #:** 03

TITLE OF COMPUTATIONS **HYDROLGIC ANALYSIS**

COMPUTATIONS BY:
Signature
Printed Name and Title: Jesus Sanchez, Senior Staff Engineer
DATE: 07/14/10

ASSUMPTIONS AND PROCEDURES CHECKED BY:
(Peer Reviewer)
Signature
Printed Name and Title: Ganesh Krishnan, PE, Associate
DATE: 7-14-2010

COMPUTATIONS CHECKED BY:
Signature
Printed Name and Title: Winsley Peter, Engineer
DATE: 7-14-2010

COMPUTATIONS BACKCHECKED BY:
(Originator)
Signature
Printed Name and Title: Jesus Sanchez, Senior Staff Engineer
DATE: 07/14/10

APPROVED BY:
(PM or Designate)
Signature
Printed Name and Title: Ganesh Krishnan, PE, Associate
DATE: 7-14-2010

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

Written by:	Jesus Sanchez	Date:	7/13/2010	Reviewed by:	Ganesh Krishnan	Date:	7/14/2010

Client:	TVA	Project:	Integrity Evaluation of Dike 2	Project/ Proposal No.:	GK4693	Task No.:	02

HYDROLOGIC ANALYSIS

PURPOSE OF ANALYSES

The purpose of this package is to calculate the peak impounded water level behind Dike 2 resulting from 100-, 500-, and 1000-year, 24-hour design storm events. Dike 2 is located at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (Site). Surface water runoff from a majority portion of the extent of the failed dredge cell areas (ash areas) and the former contributing watersheds of these respective areas (off-site areas) is discharged to the Emory River via conveyance features located at Dike 2. The analyses presented herein are intended to provide an estimate of the peak water level in the impounded area behind Dike 2 that will be used to set up scenarios for evaluating the slope stability of the dike, which is presented in Appendix B Geotechnical Integrity Evaluation.

KEY CONSIDERATIONS AND LIMITATIONS

This package addresses the conveyance of surface water runoff by the approximate drainage area that is discharged through the conveyance features located at Dike 2. This packaged does not address the surface water conditions outside limits of this drainage area and it assumed that the water level on the downward side of the dike is fixed at the summer pool elevation (i.e., 741 fee-MSL). For the analysis conducted herein it is assumed that the surface water runoff quantity from the ash and off-site areas exceeds the capacity of the conveyance features upstream of Dike 2. This assumption results in the adaptation of a fictitious modeling scenario where the effective volume of water that is impounded by Dike 2 is the flooded areas below the top of Dike 2 (pond areas).

ANALYSIS METHODOLOGY

The analyses were conducted using accepted hydraulic and hydrologic modeling procedures, and utilized methodology prescribed in Soil Conservation Service (SCS) Technical Release 55 (SCS, 1986). The analysis was conducted by developing a computer model of the contributing ash and off-site area watersheds suing the software package HydroCAD^{TM} (HydroCAD, 2009). Computer program analyses are supplemented with other design calculation methods wherever applicable.

MAJOR ASSUMPTIONS

- **Subcatchment Delineations**
  - Site Plan – Attachment 1 shows the extent of the approximated drainage area of both the ash and off-site areas that discharge through Dike 2.
  - Drainage Areas and Flowpaths **–** Attachment 2 shows the delineation of the off-site and ash areas. In addition, the flow paths of the subcatchments are shown.
  - Ash Area Components **–** Attachment 3 shows, in finer detail, the delineation of the ash areas. In addition, the extent of the fictitious pond areas, the flow paths of the ash areas, and the location of conveyance features within the flooded area below the top of Dike 2 are shown.
- **Subcatchment Properties** – Attachment 4 shows the drainage area, curve number, and travel path length, slope, and velocity factor for each subcatchment. In addition, computations are shown for the curve numbers for each subcatchment.
- **Conduit Properties** – Attachment 5 contains the information used to characterize the conveyance of surface water within the Site and to the Emory River.
- **Stage-Storage Relationships** – Attachment 6 show the area and corresponding volume at each elevation that is used in the development of stage-storage relationships for each of the ponds (flooded areas below the top of Dike 2). Tables listing the stage-storage values are also provided in this attachment.
- **Rainfall Distribution** – Attachment 7 (SCS, 1986) shows the Site to be located in the region designated as a SCS Type II Rainfall Distribution.
- **Rainfall Depth –** Rainfall depths for the 100-, 500-, and 1000-year, 24-hour design storm events were obtained through Point Precipitation Frequency Estimates from NOAA Atlas 14 (http://hdsc.nws.noaa.gov/) and are summarized below.

Return Period (years)	Rainfall Depth (inches)
100	6.77
500	8.31
1000	9.00

HYDROLOGIC MODELING

- **Nodal Network Diagram** – Attachment 8 shows the nodal network diagram showing the connectivity of the surface water subcatchments, conduits, and ponds listed below.
  - NA_1 to NA _4: Off-site area northern subcatchments
  - SA_1 to SA_2: Off-site area southern subcatchments
  - ASHBODY-1 to ASHBODY_3: Ash area subcatchments
  - PN and PC Areas: Catchment area of ponds
  - PN and PC: Pond volumes for north and central flooded areas
- **Computer Modeling** – A hydraulic and hydrologic analysis was performed using the above described assumptions using the HydroCAD computer model. The results of the modeling are presented in Attachment 9.

RESULTS

The peak impounded water level behind Dike 2 (elevation in Pond Central) arising from the 100-, 500-, and 1000-year, 24-hour design storm events are summarized below.

Return Period (years)	Rainfall Depth (inches)	Calculated Water Level (feet-MSL)	Comment
100	6.77	744.3	Calculated water level is below the emergency spillway elevation.
500	8.31	745.8	Calculated water level is below the emergency spillway elevation.
1,000	9.00	746.6	Calculated water level is 0.6 feet above the crest of the emergency spillway.

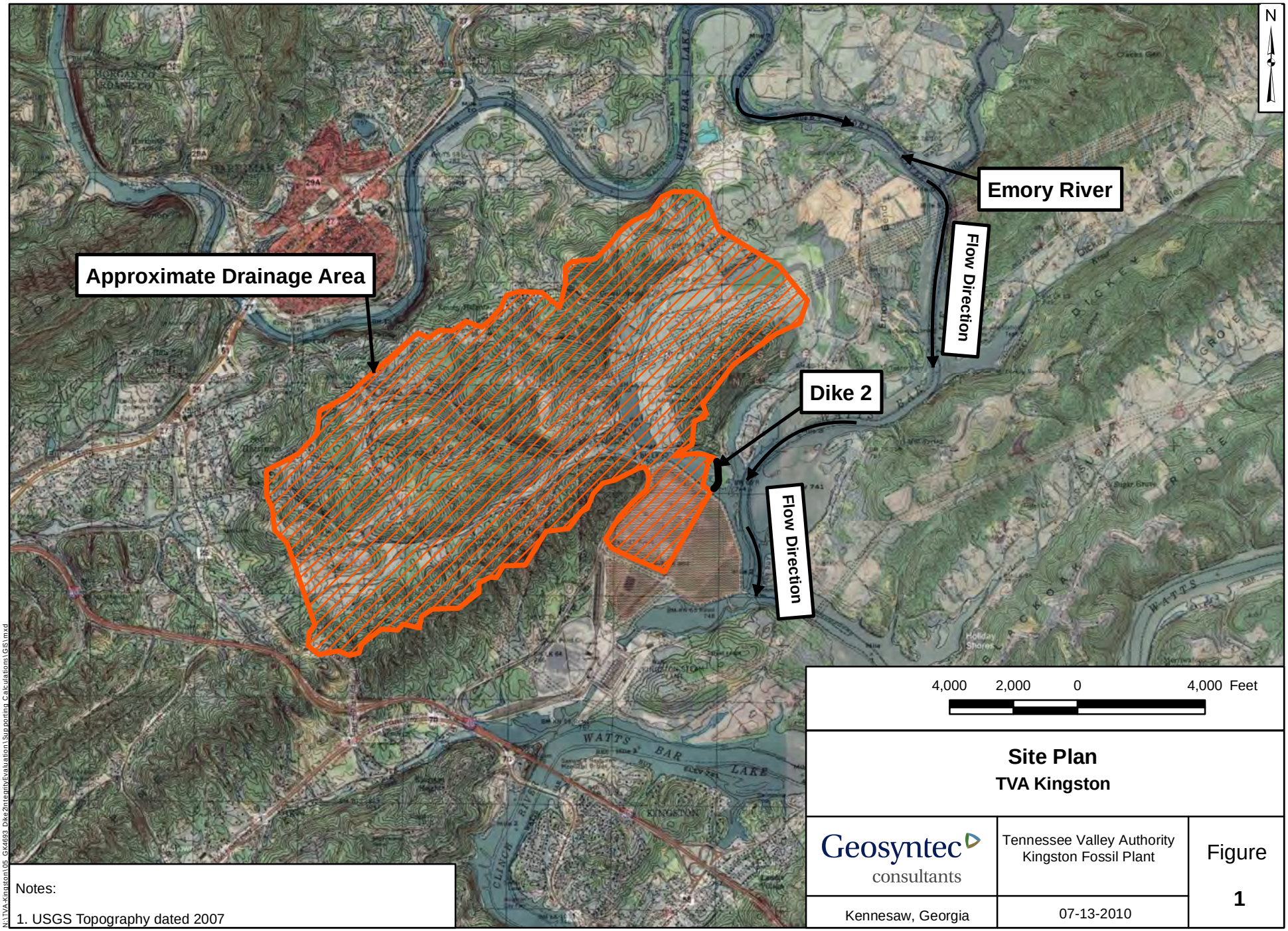
REFERENCES

HydroCAD, "HydroCAD™ Storm water Modeling System, Version 7.1", HydroCAD Software Solutions LLC., Chocorua, New Hampshire, 2005.

SCS, "Computer Program for Project Formulation—Hydrology, Technical Release 20 (TR-20)", United States Department of Agriculture, Soil Conservation Service, Washington, D.C., 1986.

SCS, "Hydrology for Small Watersheds, Technical Release 55 (TR-55)", United States Department of Agriculture, Soil Conservation Service, Washington, D.C., 1986.

Attachment 1 – Site Plan



Notes:

1. USGS Topography dated 2007

Site Plan

TVA Kingston

Geosyntec consultants	Tennessee Valley Authority Kingston Fossil Plant	Figure **1**
Kennesaw, Georgia	07-13-2010	

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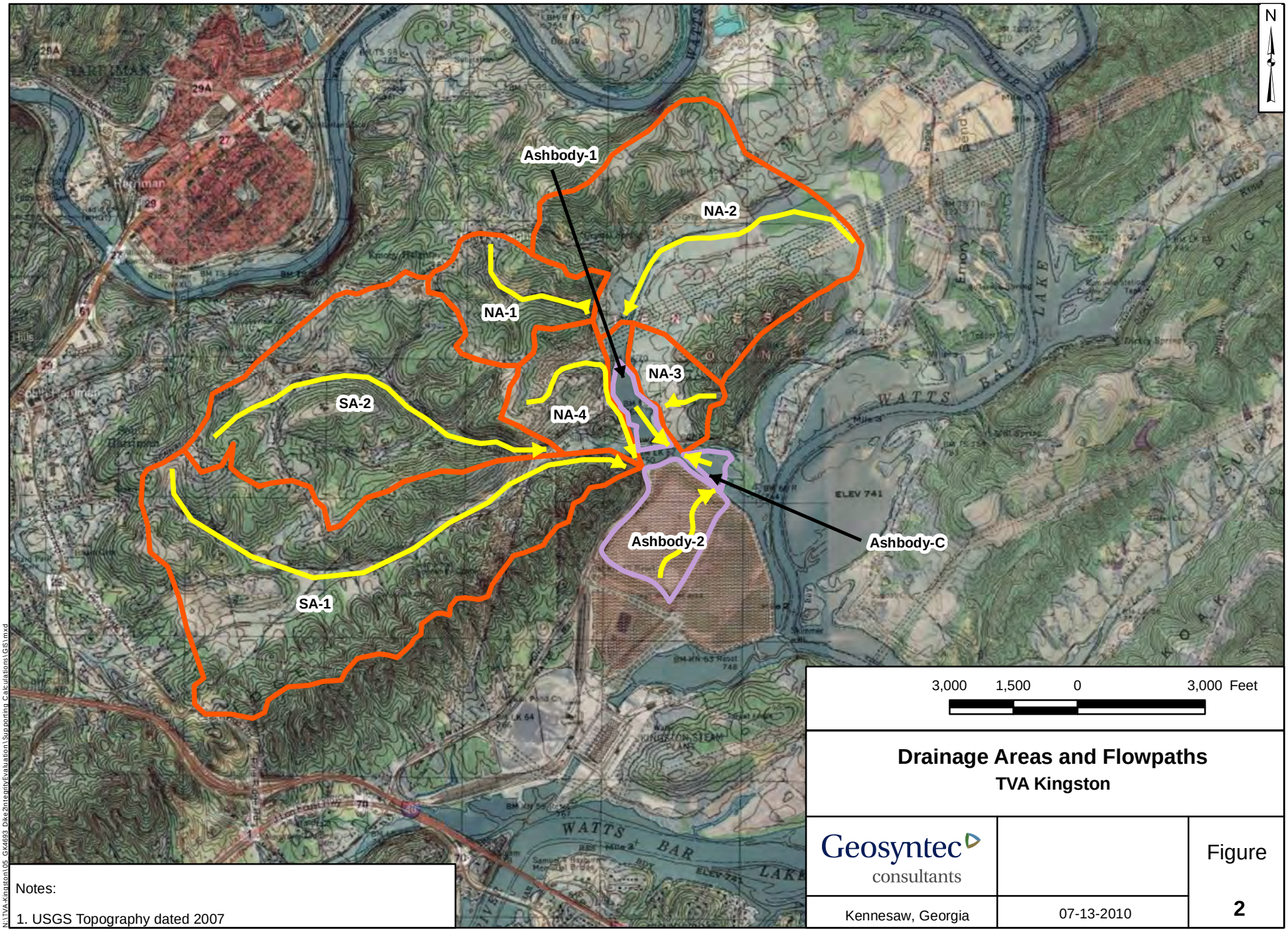
Written by: **Jesus Sanchez** Date: **7/13/2010** Reviewed by: **Ganesh Krishnan** Date: **7/14/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **02**

Attachment 2 – Drainage Areas and Flowpaths



Notes:

1. USGS Topography dated 2007

Drainage Areas and Flowpaths
TVA Kingston

Geosyntec consultants

Kennesaw, Georgia

07-13-2010

Figure 2

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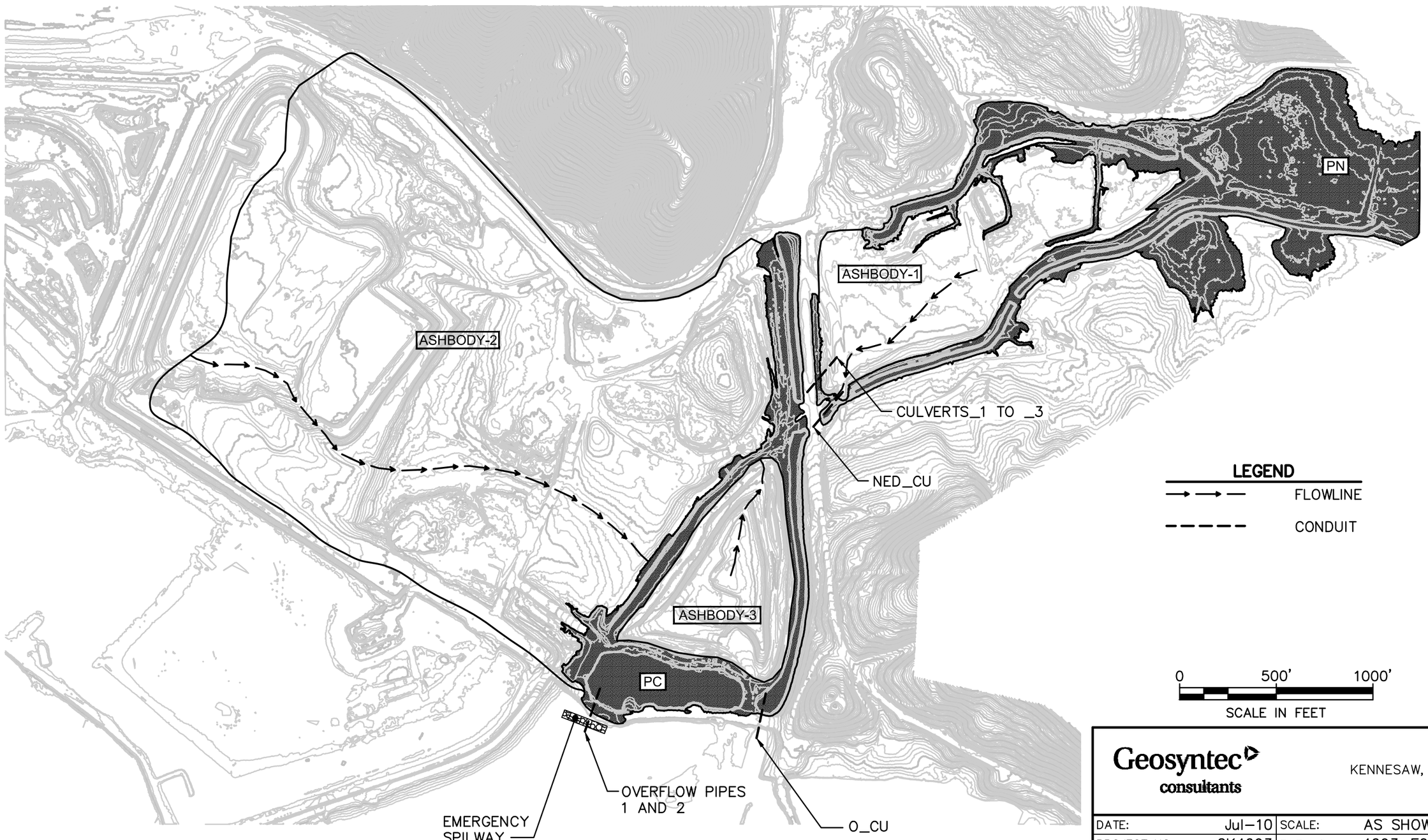
Attachment 3 – Ash Area Components

ASH AREA COMPONENTS



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KENNESAW, GA

DATE:	Jul–10	SCALE:	AS SHOWN
PROJECT NO.	GK4693	FILE NO.	4693–F001
DOCUMENT NO.	–	FIGURE NO.	3

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Written by:	Jesus Sanchez	Date:	7/13/2010	Reviewed by:	Ganesh Krishnan	Date:	7/14/2010

Client:	TVA	Project:	Integrity Evaluation of Dike 2	Project/ Proposal No.:	GK4693	Task No.:	02

Attachment 4 – Subcatchment Properties

Written by: Winsley Peter
Date: 07/13/2010
Client: TVA
Project: Integrity Evaluation of Dike 2

Subcatchment Properties Summary Table

Reviewed by: Jesus Sanchez
Date: 07/13/2010
Client: TVA
Project: Integrity Evaluation of Dike 2

Subcatchment ID	Area	Curve Number	Overland Flow						Time of Concentration
			Length	Upstream Elevation	Downstream Elevation	Slope	Velocty Factor (K)	Velocity	
	(acres)		(ft)	(ft)	(ft)	(ft/ft)	-	(ft/s)	(minutes)
SA_1	882.0	66.00	12641	1054	870	0.0146	5	0.60	349
SA_2	624.0	58.00	8746	1033	764	0.0308	5	0.88	166
NA_1	176.0	58.00	3358	900	813	0.0259	5	0.80	70
NA_2	646.0	61.00	6729	764	740	0.0036	7	0.42	268
NA_3	84.0	59.00	1252	871	754	0.0935	7	2.14	10
NA_4	148.0	61.00	4599	926	743	0.0398	7	1.40	55
ASHBODY-1	24.4	91.00	1058	756	748	0.0076	10	0.87	20.3
ASHBODY-2	127.5	91.00	2755	818	750	0.0247	10	1.57	29.2
ASHBODY-3	13.6	91.00	647	788	744	0.0680	10	2.61	4.1

Total Area= **2725.50**

Notes:
1) Velcoity Factor [5.0 -woodlands, 7.0 - short grass pasture, 10 - Ash(nearly bare)]
2) Slope = (Upstream Elevation - Downstream Elevation)/ Length
3) Velocity = Kv * S^ 0.5
4) Time of Concentration = L/V

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Project No. GK4693
Phase No. 02

Written by: Winsley Peter
Date: 07/13/2010
Client: TVA
Project: Integrity Evaluation of Dike 2

Subcatchment Properties
Composite Curve Number Computation

Reviewed: Jesus Sanchez
Date: 07/13/2010
Client: TVA
Project: Integrity Evaluation of Dike 2

SA_1	882.00			
Percentage	**Area**	**Soil Group**	**CN**	**CN x A**
7.5%	66.2	C	72	4763
0.2%	1.8	C	91	161
2.9%	25.6	B	58	1484
1.1%	9.7	B	58	563
3.0%	26.5	B	58	1535
2.6%	22.9	B	58	1330
10.9%	96.1	B	58	5576
28.4%	250.5	B	58	14528
5.2%	45.9	B	58	2660
1.3%	11.5	D	79	906
2.4%	21.2	B	58	1228
28.1%	247.8	D	79	19580
1.9%	16.8	C	72	1207
4.6%	40.6	C	72	2921
			SUM =	58440
			CN =	**66**

SA_2	624.00			
Percentage	**Area**	**Soil Group**	**CN**	**CN x A**
18.8%	117.3	B	58	6804
1.9%	11.9	B	58	688
1.3%	8.1	B	58	470
6.8%	42.4	B	58	2461
6.6%	41.2	B	58	2389
64.2%	400.6	B	58	23235
0.5%	3.1	D	58	181
			SUM =	36228
			CN =	**58**

NA_1	176.00			
Percentage	**Area**	**Soil Group**	**CN**	**CN x A**
14.2%	25.0	B	58	1450
5.2%	9.2	B	58	531
7.9%	13.9	B	58	806
2.4%	4.2	B	58	245
69.8%	122.8	B	58	7125
0.5%	0.9	B	58	51
			SUM =	10208
			CN =	**58**

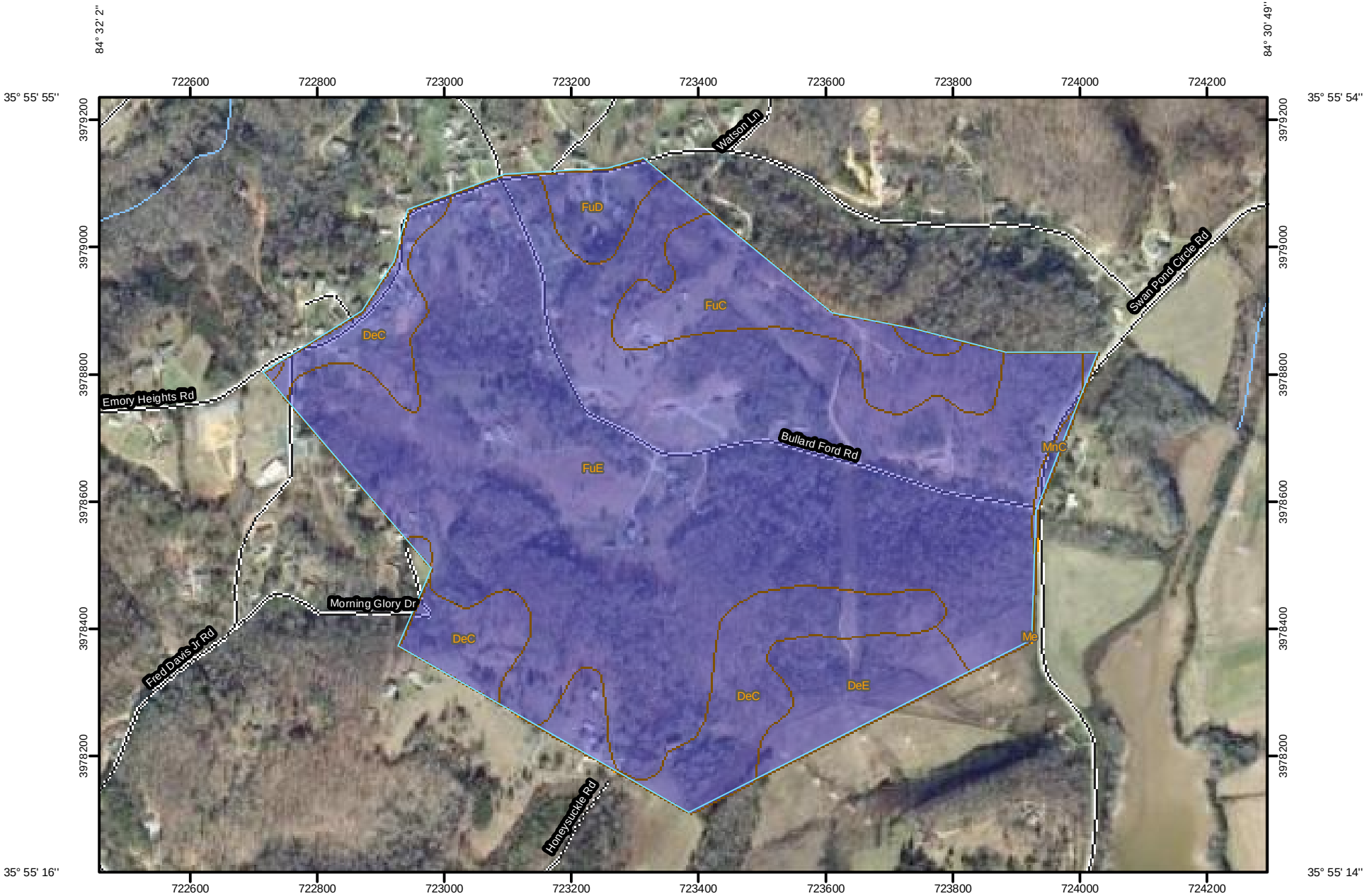
NA_2	646.00			
Percentage	**Area**	**Soil Group**	**CN**	**CN x A**
4.5%	29.1	B	58	1686
3.7%	23.9	B	58	1386
1.8%	11.6	B	58	674
8.5%	54.9	B	58	3185
7.2%	46.5	B	58	2698
2.9%	18.7	B	58	1087
1.8%	11.6	B	58	674
3.8%	24.5	B	58	1424
25.9%	167.3	B	58	9704
0.1%	0.6	C	72	47
5.8%	37.5	B	58	2173
1.0%	6.5	B	58	375
14.5%	93.7	D	79	7400
6.3%	40.7	B	58	2360
0.8%	5.2	C	72	372
0.5%	3.2		100	323
2.1%	13.6	B	58	787
5.7%	36.8	B	58	2136
2.8%	18.1	B	58	1049
0.2%	1.3	C	72	93
			SUM =	39633
			CN =	**61**

NA_3	84.00			
Percentage	**Area**	**Soil Group**	**CN**	**CN x A**
19.2%	16.1	B	58	935
7.8%	6.6	B	58	380
5.1%	4.3	B	58	248
13.0%	10.9	B	58	633
34.0%	28.6	B	58	1656
3.3%	2.8	B	58	161
1.8%	1.5	D	79	119
0.5%	0.4		100	42
12.3%	10.3	B	58	599
2.9%	2.4	B	58	141
			SUM =	4917
			CN =	**59**

NA_4	148.00			
Percentage	**Area**	**Soil Group**	**CN**	**CN x A**
1.5%	2.2	B	58	129
11.1%	16.4	B	58	953
7.1%	10.5	B	58	609
46.5%	68.8	B	58	3992
5.9%	8.7	B	58	506
4.7%	7.0	B	58	403
12.5%	18.5	D	79	1462
0.2%	0.3	B	58	17
7.4%	11.0	D	79	865
0.9%	1.3	D	79	105
			SUM =	9042
			CN =	**61**

Notes:
1) Soil Group distribution in each subcatchment is detailed in Attachment 4.
2) Off-site subcatchments assumed to have Woods-grass combination (good condition) land use type from investigation of aerial orthographic photographs.
3) A CN of 100 is applied to water surfaces per recommendations in HydroCAD 9.1.

Hydrologic Soil Group—Roane County, Tennessee
(NBA-1)



NA_1

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:8,720 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Roane County, Tennessee
Survey Area Data: Version 7, Sep 23, 2009

Date(s) aerial images were photographed: 12/5/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Roane County, Tennessee				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
DeC	Dewey silt loam, 5 to 12 percent slopes	B	28.4	14.2%
DeE	Dewey silt loam, 20 to 45 percent slopes	B	10.3	5.2%
FuC	Fullerton-Pailo complex, 5 to 12 percent slopes	B	15.8	7.9%
FuD	Fullerton-Pailo complex, 12 to 20 percent slopes	B	4.7	2.4%
FuE	Fullerton-Pailo complex, 20 to 35 percent slopes	B	139.1	69.8%
Me	Melvin silt loam, frequently flooded	D	0.0	0.0%
MnC	Minvale gravelly silt loam, 5 to 12 percent slopes	B	1.0	0.5%
Totals for Area of Interest			**199.4**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

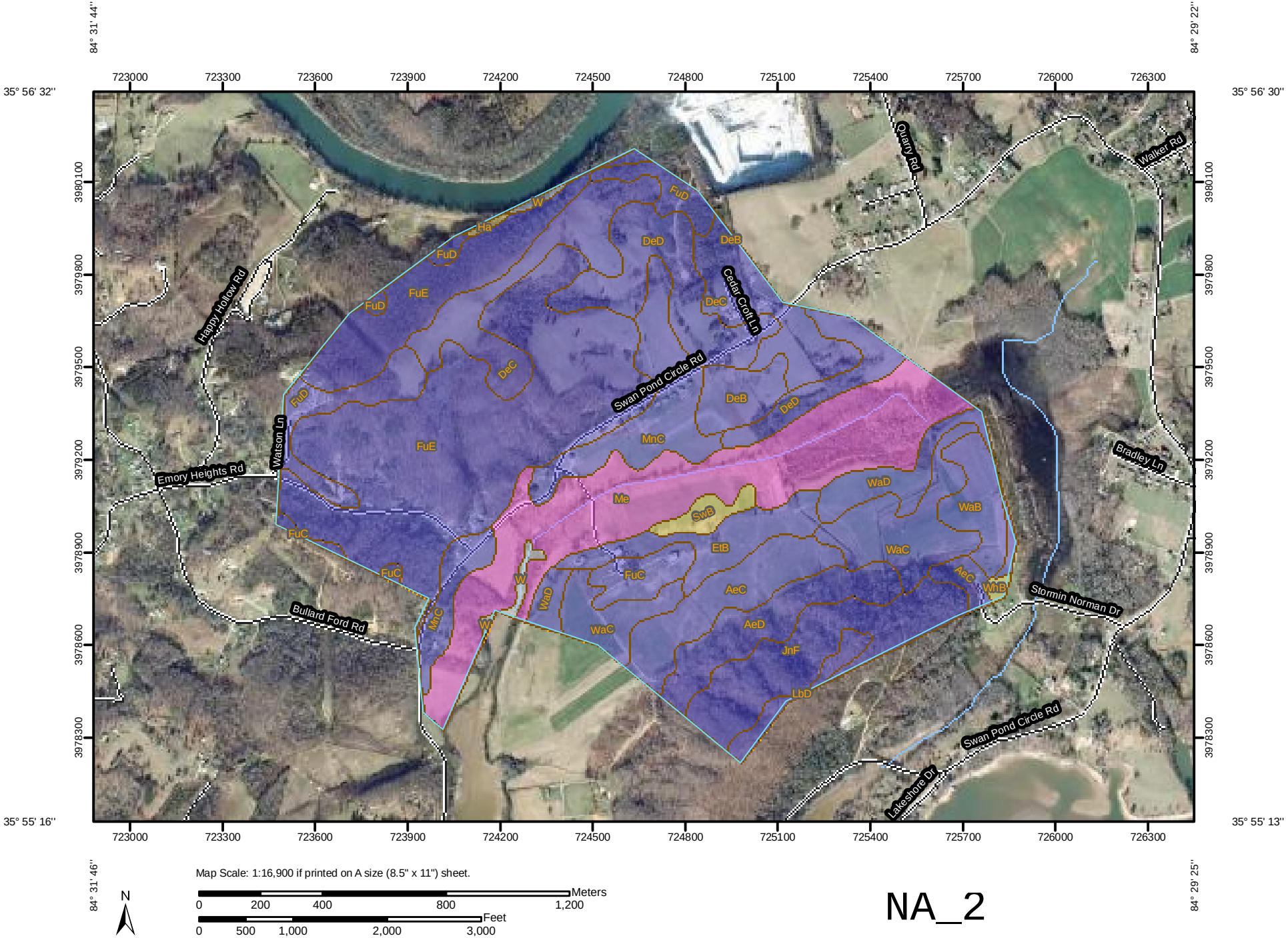
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Hydrologic Soil Group—Roane County, Tennessee
(NBA-2)



NA_2

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:16,900 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Roane County, Tennessee
Survey Area Data: Version 7, Sep 23, 2009

Date(s) aerial images were photographed: 12/5/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Roane County, Tennessee				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
AeC	Allen loam, 5 to 12 percent slopes	B	31.8	4.5%
AeD	Allen loam, 12 to 20 percent slopes	B	26.3	3.7%
DeB	Dewey silt loam, 2 to 5 percent slopes	B	12.9	1.8%
DeC	Dewey silt loam, 5 to 12 percent slopes	B	59.8	8.5%
DeD	Dewey silt loam, 12 to 20 percent slopes	B	50.7	7.2%
EtB	Etowah loam, 2 to 5 percent slopes	B	20.2	2.9%
FuC	Fullerton-Pailo complex, 5 to 12 percent slopes	B	12.8	1.8%
FuD	Fullerton-Pailo complex, 12 to 20 percent slopes	B	26.6	3.8%
FuE	Fullerton-Pailo complex, 20 to 35 percent slopes	B	182.2	25.9%
Ha	Hamblen silt loam, occasionally flooded	C	0.8	0.1%
JnF	Jefferson cobbly loam, 20 to 50 percent slopes	B	40.6	5.8%
LbD	Lily loam, 12 to 20 percent slopes	B	7.0	1.0%
Me	Melvin silt loam, frequently flooded	D	101.6	14.5%
MnC	Minvale gravelly silt loam, 5 to 12 percent slopes	B	44.2	6.3%
SwB	Swafford loam, 2 to 5 percent slopes	C	5.9	0.8%
W	Water		3.4	0.5%
WaB	Waynesboro loam, 2 to 5 percent slopes	B	14.8	2.1%
WaC	Waynesboro loam, 5 to 12 percent slopes	B	39.9	5.7%
WaD	Waynesboro loam, 12 to 20 percent slopes	B	19.9	2.8%
WhB	Whitwell loam, 1 to 4 percent slopes, occasionally flooded	C	1.3	0.2%
Totals for Area of Interest			**702.8**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

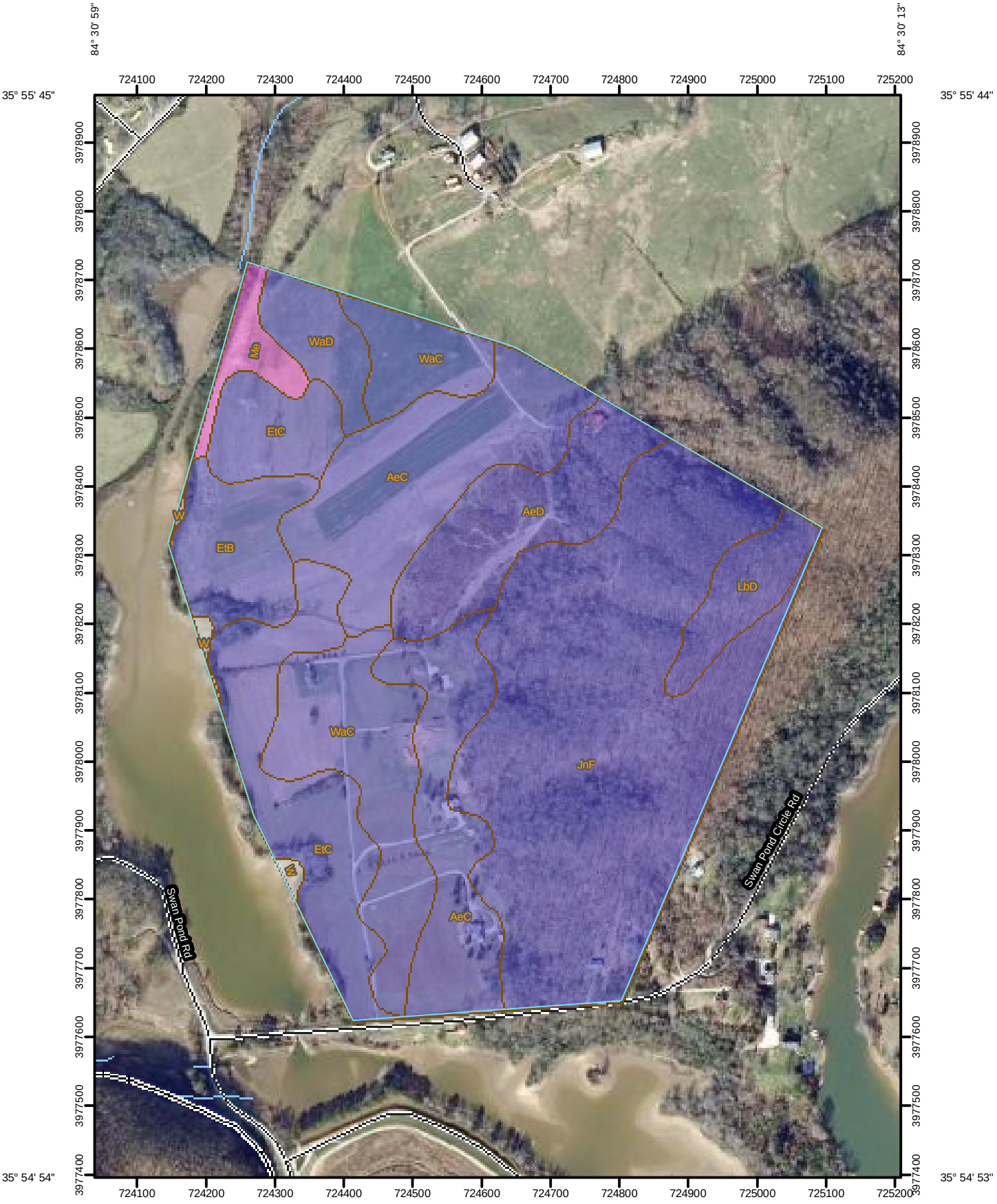
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower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3978500
3978400
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3978200
3978100
3978000
3977900
3977800
3977700
3977600
3977500
3977400
Me
WaD
WaC
EtC
AeC
AeD
EtB
LbD
JnF
Swan Pond Rd
Swan Pond Circle Rd
N
Map Scale: 1:7,510 if printed on A size (8.5" x 11") sheet.
Meters
0 50 100 200 300
Feet
0 250 500 1,000 1,500

NA_3

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:7,510 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Roane County, Tennessee
Survey Area Data: Version 7, Sep 23, 2009

Date(s) aerial images were photographed: 12/5/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Roane County, Tennessee				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
AeC	Allen loam, 5 to 12 percent slopes	B	32.6	19.2%
AeD	Allen loam, 12 to 20 percent slopes	B	13.3	7.8%
EtB	Etowah loam, 2 to 5 percent slopes	B	8.7	5.1%
EtC	Etowah silt loam, 5 to 12 percent slopes	B	22.1	13.0%
JnF	Jefferson cobbly loam, 20 to 50 percent slopes	B	57.8	34.0%
LbD	Lily loam, 12 to 20 percent slopes	B	5.6	3.3%
Me	Melvin silt loam, frequently flooded	D	3.1	1.8%
W	Water		0.8	0.5%
WaC	Waynesboro loam, 5 to 12 percent slopes	B	20.9	12.3%
WaD	Waynesboro loam, 12 to 20 percent slopes	B	5.0	2.9%
Totals for Area of Interest			**169.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

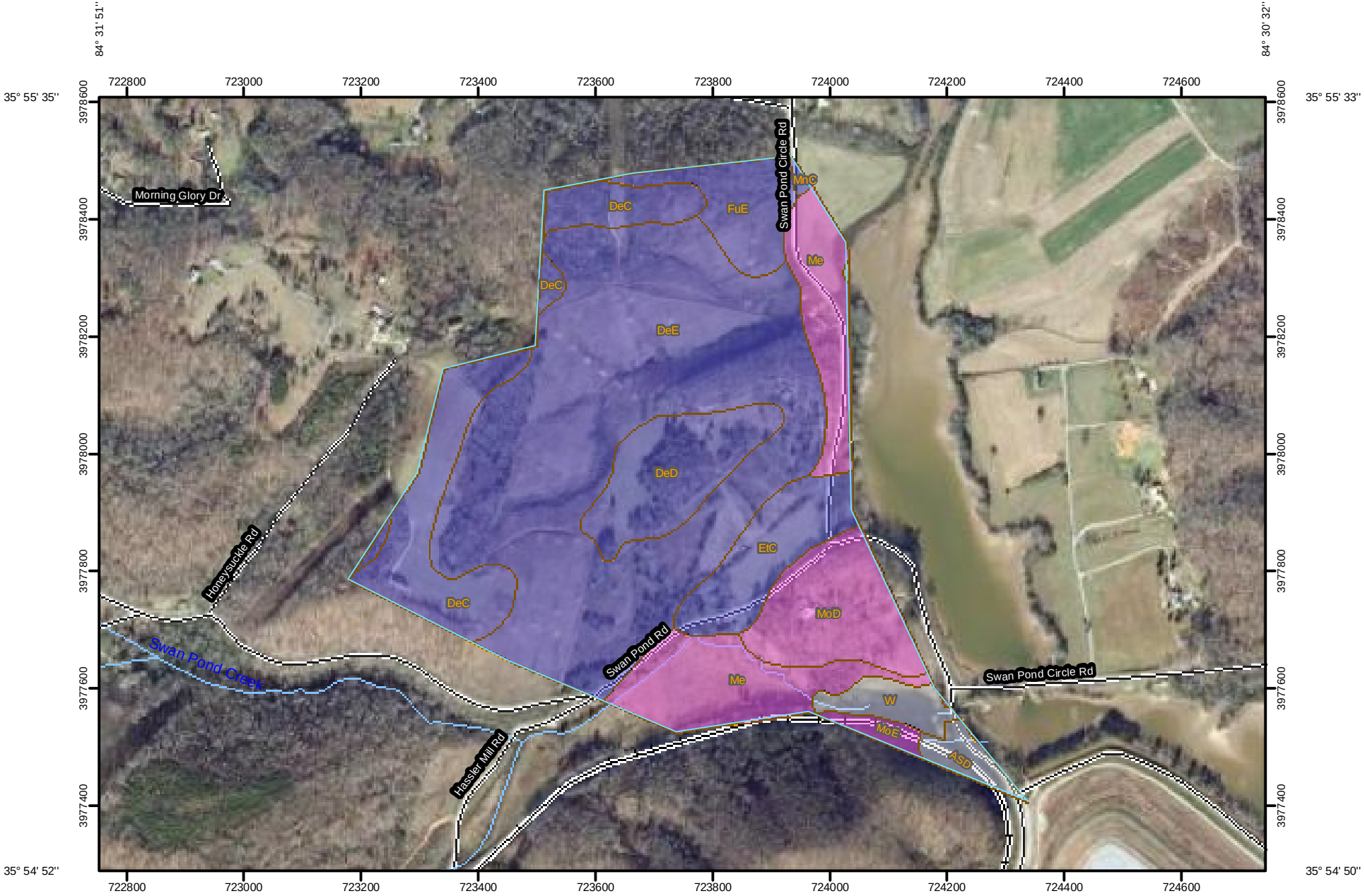
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Hydrologic Soil Group—Roane County, Tennessee
(ONSITE AREA)



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Meters
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Feet
0 500 1,000 2,000 3,000

NA_4

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:9,440 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Roane County, Tennessee
Survey Area Data: Version 7, Sep 23, 2009

Date(s) aerial images were photographed: 12/5/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Roane County, Tennessee				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
ASD	Ash disposal area		2.4	1.5%
DeC	Dewey silt loam, 5 to 12 percent slopes	B	17.6	11.1%
DeD	Dewey silt loam, 12 to 20 percent slopes	B	11.3	7.1%
DeE	Dewey silt loam, 20 to 45 percent slopes	B	73.6	46.5%
EtC	Etowah silt loam, 5 to 12 percent slopes	B	9.3	5.9%
FuE	Fullerton-Pailo complex, 20 to 35 percent slopes	B	7.4	4.7%
Me	Melvin silt loam, frequently flooded	D	19.8	12.5%
MnC	Minvale gravelly silt loam, 5 to 12 percent slopes	B	0.3	0.2%
MoD	Montevallo channery silt loam, 12 to 20 percent slopes	D	11.6	7.4%
MoE	Montevallo channery silt loam, 20 to 35 percent slopes	D	1.4	0.9%
W	Water		3.6	2.3%
Totals for Area of Interest			**158.4**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

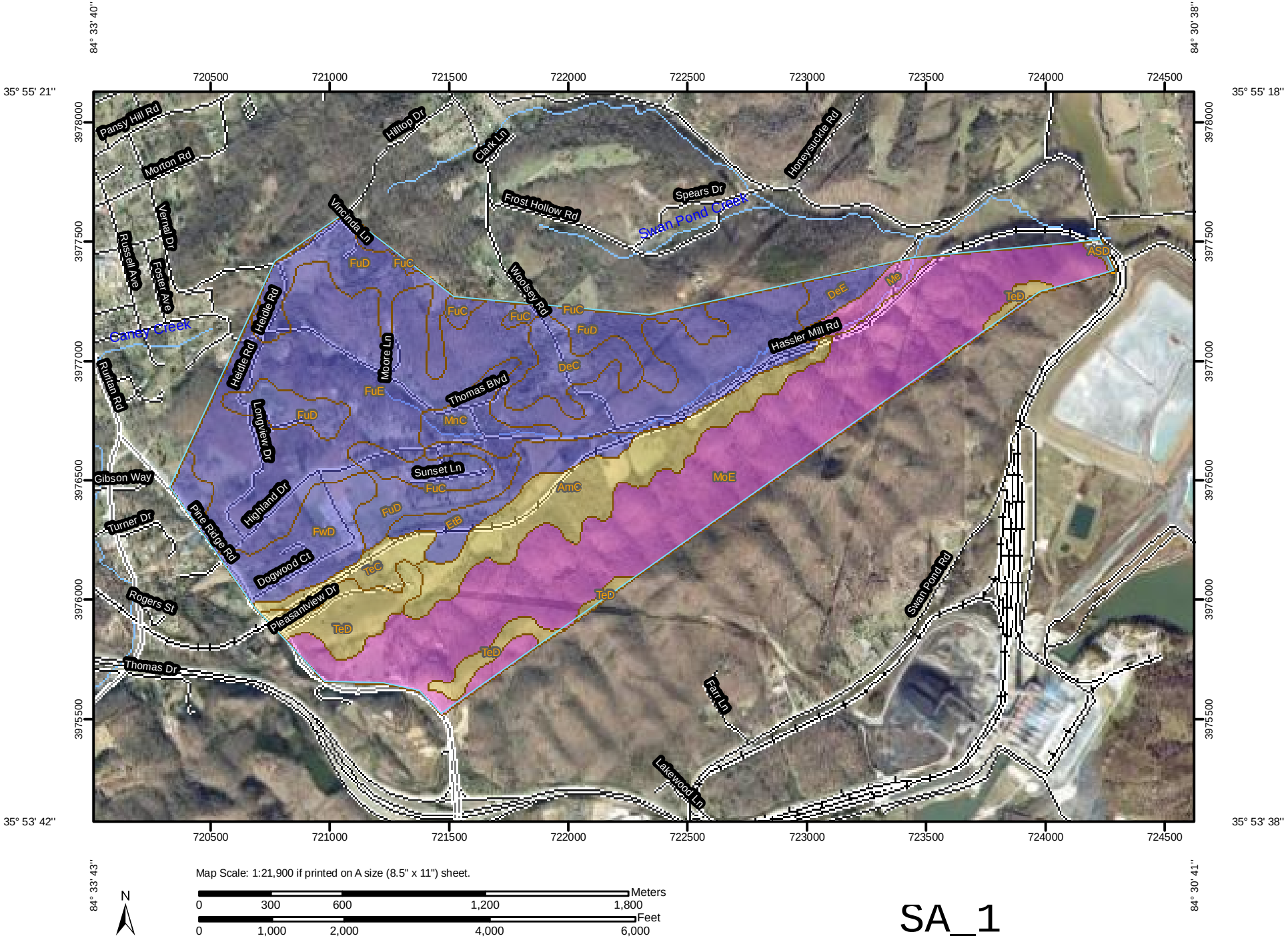
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower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84° 30' 38"
35° 55' 21"
35° 55' 18"
35° 53' 42"
35° 53' 38"
84° 33' 43"
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721000
721500
722000
722500
723000
723500
724000
724500
3978000
3977500
3977000
3976500
3976000
3975500
Pansy Hill Rd
Morton Rd
Vernal Dr
Russell Ave
Foster Ave
Candy Creek
Runfan Rd
Gibson Way
Turner Dr
Rogers St
Thomas Dr
Hilltop Dr
Clark Ln
Vincinda Ln
Heidle Rd
Longview Dr
Moore Ln
Thomas Blvd
Sunset Ln
Highland Dr
Pine Ridge Rd
Dogwood Ct
Pleasantview Dr
Frost Hollow Rd
Spears Dr
Swan Pond Creek
Honeysuckle Rd
Woolsey Rd
Hassler Mill Rd
Swan Pond Rd
Farr Ln
Lakewood Ln
FuD
FuC
FuE
DeC
DeE
MnC
AmC
MoE
EtB
FwD
TeC
TeD
Me
ASD
Map Scale: 1:21,900 if printed on A size (8.5" x 11") sheet.
N
Meters
0
300
600
1,200
1,800
Feet
0
1,000
2,000
4,000
6,000
SA_1

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:21,900 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Roane County, Tennessee
Survey Area Data: Version 7, Sep 23, 2009

Date(s) aerial images were photographed: 12/5/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Roane County, Tennessee				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
AmC	Armuchee silt loam, 5 to 12 percent slopes	C	73.1	7.5%
ASD	Ash disposal area		1.7	0.2%
DeC	Dewey silt loam, 5 to 12 percent slopes	B	27.8	2.9%
DeE	Dewey silt loam, 20 to 45 percent slopes	B	11.0	1.1%
EtB	Etowah loam, 2 to 5 percent slopes	B	28.9	3.0%
FuC	Fullerton-Pailo complex, 5 to 12 percent slopes	B	24.9	2.6%
FuD	Fullerton-Pailo complex, 12 to 20 percent slopes	B	106.0	10.9%
FuE	Fullerton-Pailo complex, 20 to 35 percent slopes	B	276.9	28.4%
FwD	Fullerton-Dewey-Urban land complex, 5 to 20 percent slopes	B	50.3	5.2%
Me	Melvin silt loam, frequently flooded	D	13.1	1.3%
MnC	Minvale gravelly silt loam, 5 to 12 percent slopes	B	23.4	2.4%
MoE	Montevallo channery silt loam, 20 to 35 percent slopes	D	274.2	28.1%
TeC	Townley silt loam, 5 to 12 percent slopes	C	18.3	1.9%
TeD	Townley silt loam, 12 to 20 percent slopes	C	44.7	4.6%
Totals for Area of Interest			**974.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

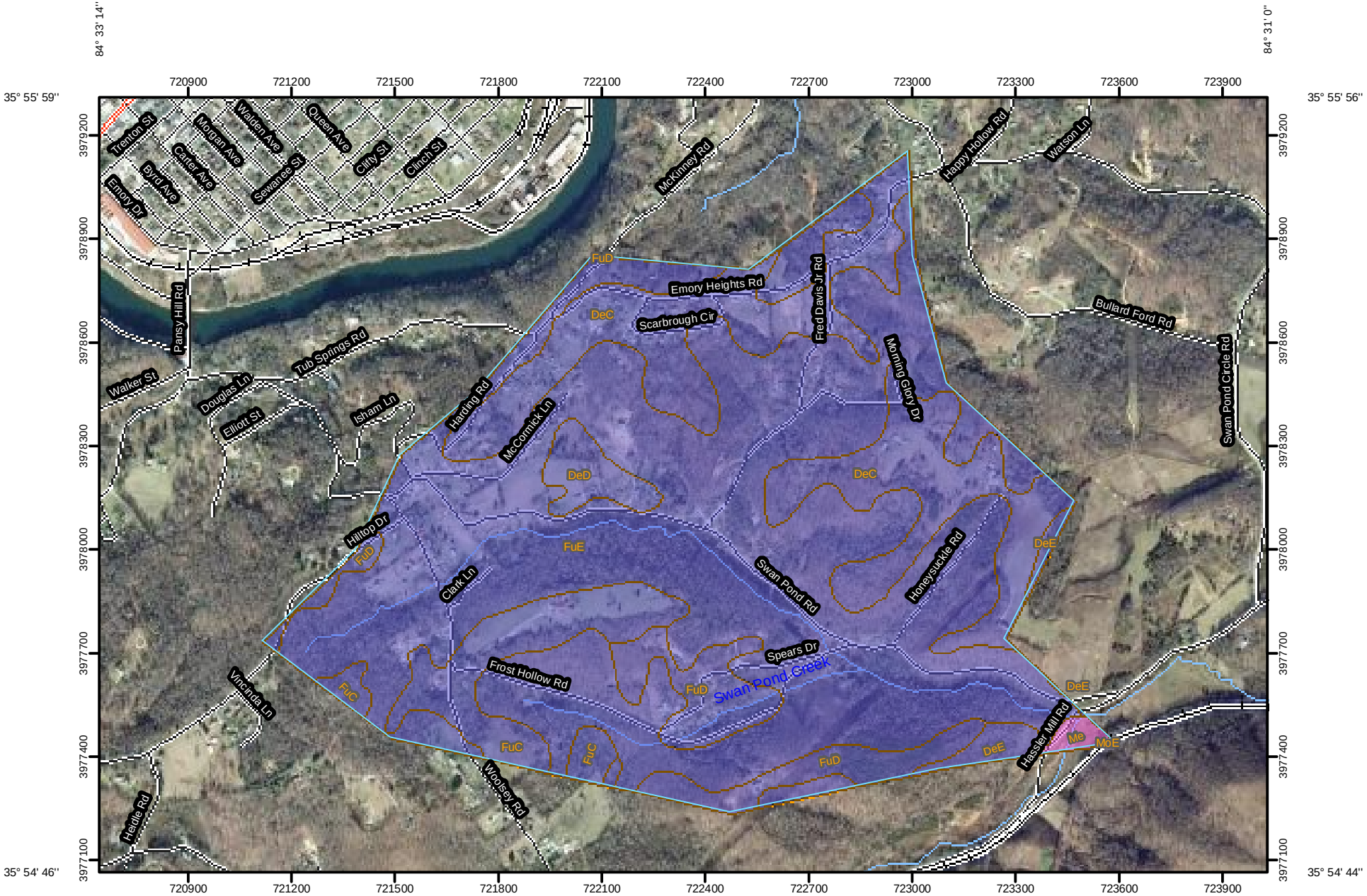
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower



Map Scale: 1:16,100 if printed on A size (8.5" x 11") sheet.

N

Meters
0 200 400 800 1,200

Feet
0 500 1,000 2,000 3,000

SA_2

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Oceans
- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:16,100 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 16N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Roane County, Tennessee
Survey Area Data: Version 7, Sep 23, 2009

Date(s) aerial images were photographed: 12/5/2006

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Roane County, Tennessee				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
DeC	Dewey silt loam, 5 to 12 percent slopes	B	125.5	18.8%
DeD	Dewey silt loam, 12 to 20 percent slopes	B	12.4	1.9%
DeE	Dewey silt loam, 20 to 45 percent slopes	B	8.6	1.3%
FuC	Fullerton-Pailo complex, 5 to 12 percent slopes	B	45.2	6.8%
FuD	Fullerton-Pailo complex, 12 to 20 percent slopes	B	44.4	6.6%
FuE	Fullerton-Pailo complex, 20 to 35 percent slopes	B	429.6	64.2%
Me	Melvin silt loam, frequently flooded	D	3.3	0.5%
MoE	Montevallo channery silt loam, 20 to 35 percent slopes	D	0.1	0.0%
Totals for Area of Interest			**669.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group Asoils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group Bsoils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group Csoils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group Dsoils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983).

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Attachment 5 – Conduit Properties

Conduit Properties

Conduits discharging from PN to PC:

Conduit Name: Culvert_1, _2, _3

Length (feet):	68, 66, 66
Inlet Invert Elevation (feet-MSL):	747.1, 745, 745.3
Outlet Invert Elevation (feet-MSL):	745
Dimensions:	48" diameter pipe
Pipe Material:	Corrugated Metal Pipe; Manning's n = 0.030
Entrance Type:	Projecting, no headwall

Note: Specifications as shown on page 10W290_08 of drawing package.

Conduit Name: North Embayment Discharge Culverts (NED_CU)

Length (feet):	137
Inlet Invert Elevation (feet-MSL):	738.5
Outlet Invert Elevation (feet-MSL):	738.0
Dimensions:	2x63" diameter pipe; 58.8" inside diameter
Pipe Material:	HDPE; Manning's n = 0.011
Entrance Type:	Mitered to conform to fill

Note: Specifications as shown on page 10W290_08 of drawing package.

Conduits discharging from PC to Emory River:

Conduit Name: Overflow Pipe 1 & 2

Inlet Invert Elevation (feet-MSL):	743.0, 743.5
Dimensions:	60" diameter pipe

Note: Specifications as shown on page 10W290_04 of drawing package.

Conduit Name: Outlet Culverts (O_CU)

Length (feet):	115
Inlet Invert Elevation (feet-MSL):	736.5
Outlet Invert Elevation (feet-MSL):	736.0
Dimensions:	5x63" diameter pipe; 58.8" inside diameter
Pipe Material:	HDPE; Manning's n = 0.011
Entrance Type:	Mitered to conform to fill

Note: Specifications as shown on page 10W290_08 of drawing package.

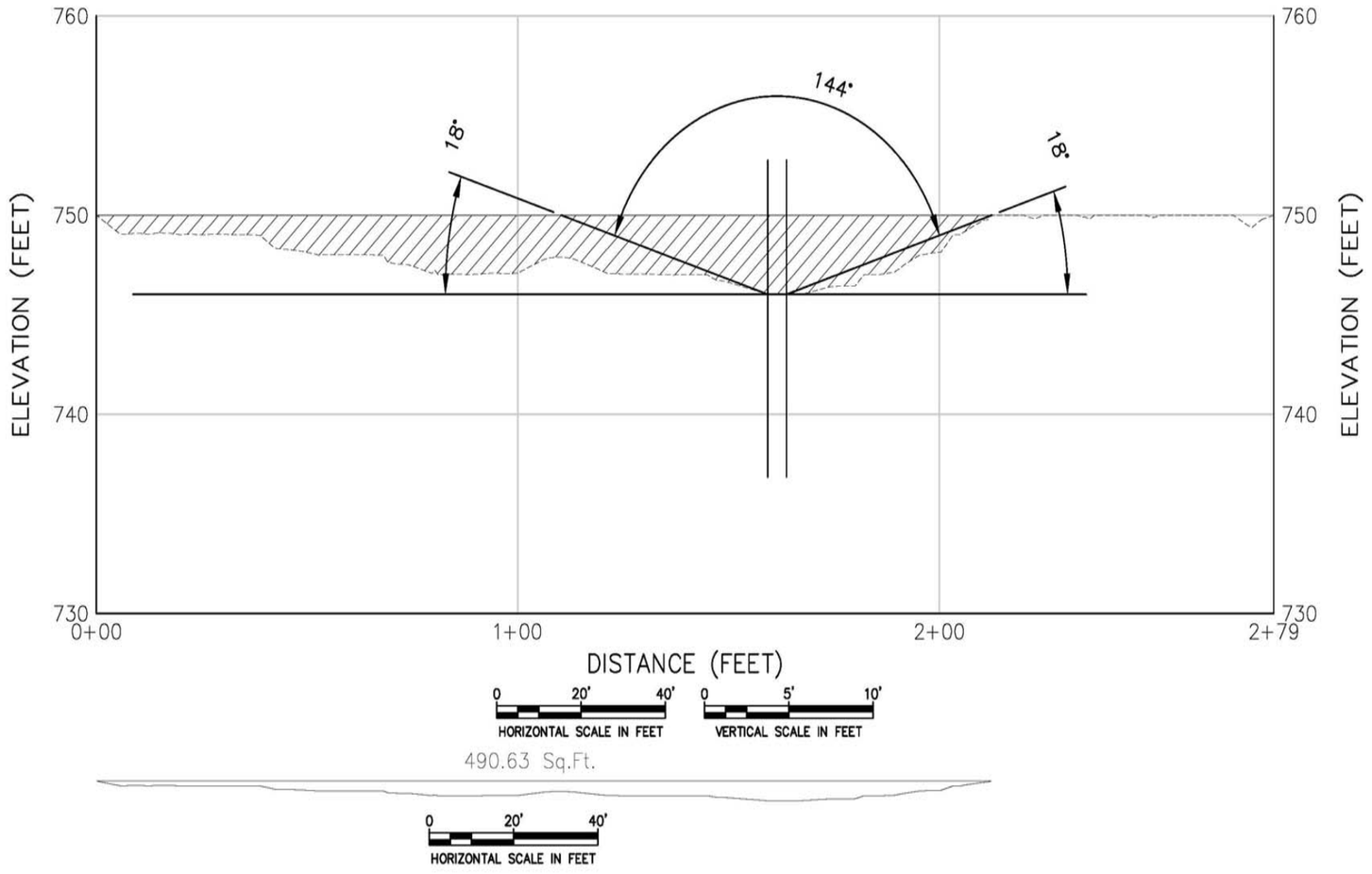
Conduit Properties

Conduits discharging from PC to Emory River (continued):

Conduit Name: Emergency Spillway (Spillway)

Crest Invert Elevation (feet-MSL):	746
Crest Length (feet):	4.4
Notch Angle (degrees):	144.0
Rise (feet)	4

Note: Dimensions taken from 05-19-10 topographic data as shown on this page.

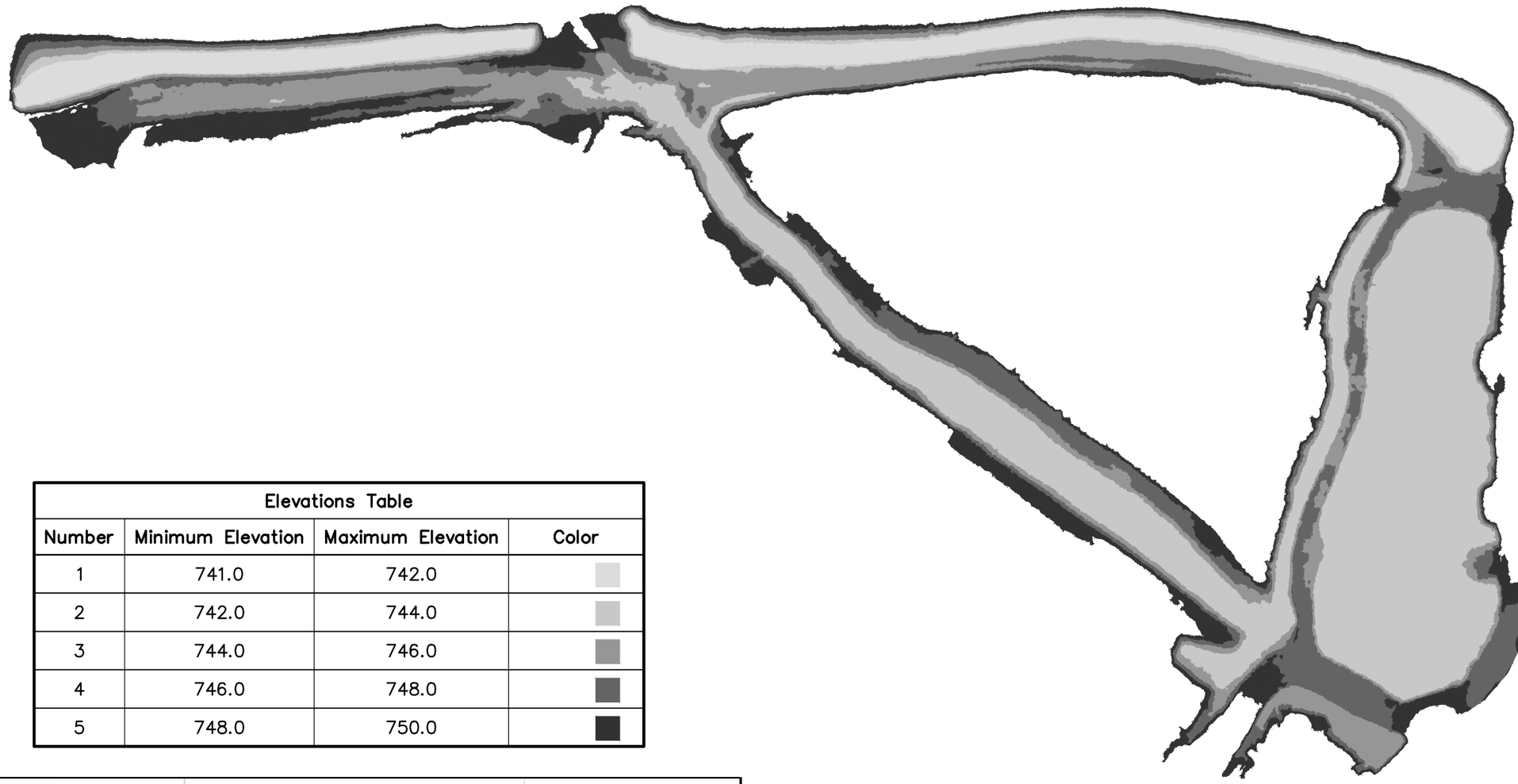


Written by: **Jesus Sanchez** Date: **7/13/2010** Reviewed by: **Ganesh Krishnan** Date: **7/14/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **02**

Attachment 6 –Stage-Storage Relationships

STAGE-STORAGE RELATIONSHIP FOR PC



N

Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	741.0	742.0	
2	742.0	744.0	
3	744.0	746.0	
4	746.0	748.0	
5	748.0	750.0	

POND CENTRAL

ELEVATIONS	CUBIC YARDS	ACRE-FEET
741.0	0.0	0.0
742.0	3190.0	2.0
744.0	23862.9	14.8
746.0	58997.6	36.6
748.0	106274.2	65.9
750.0	162974.5	101.0

0 200' 400'

SCALE IN FEET

Geosyntec consultants

KENNESAW, GA

DATE:	Jul–10	SCALE:	AS SHOWN
PROJECT NO.	GK4693	FILE NO.	4693F004
DOCUMENT NO.	–	FIGURE NO.	6A

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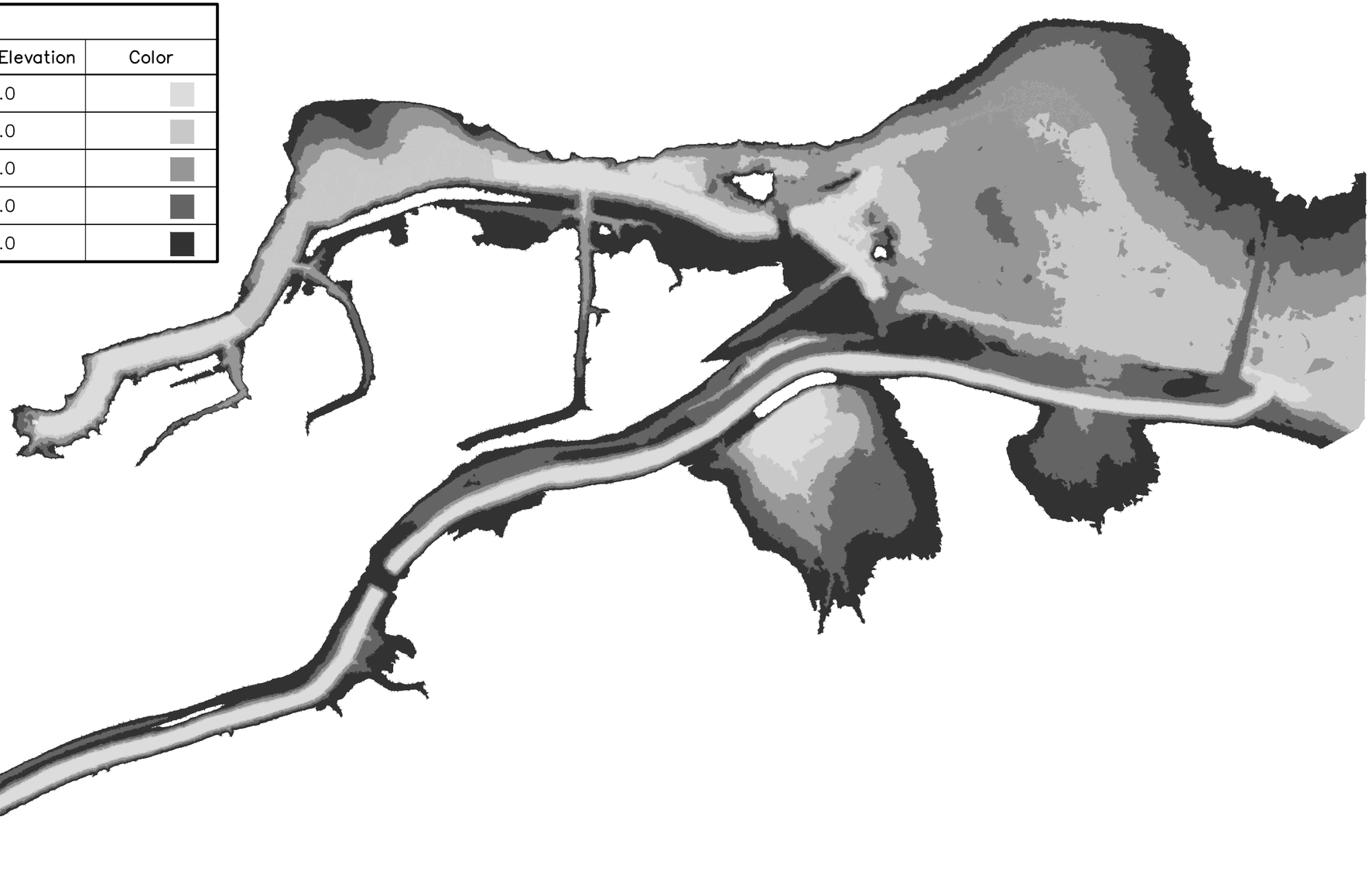
STAGE-STORAGE RELATIONSHIP FOR PN

Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	741.0	742.0	
2	742.0	744.0	
3	744.0	746.0	
4	746.0	748.0	
5	748.0	750.0	



POND NORTH

ELEVATIONS	CUBIC YARDS	ACRE-FEET
741.0	0.0	0.0
742.0	3247.7	2.0
744.0	25321.8	15.7
746.0	76367.7	47.3
748.0	151531.4	93.9
750.0	255210.3	158.2

0 250' 500'

SCALE IN FEET

Geosyntec consultants

KENNESAW, GA

DATE:	Jul–10	SCALE:	AS SHOWN
PROJECT NO.	GK4693	FILE NO.	4693F005
DOCUMENT NO.	–	FIGURE NO.	6B

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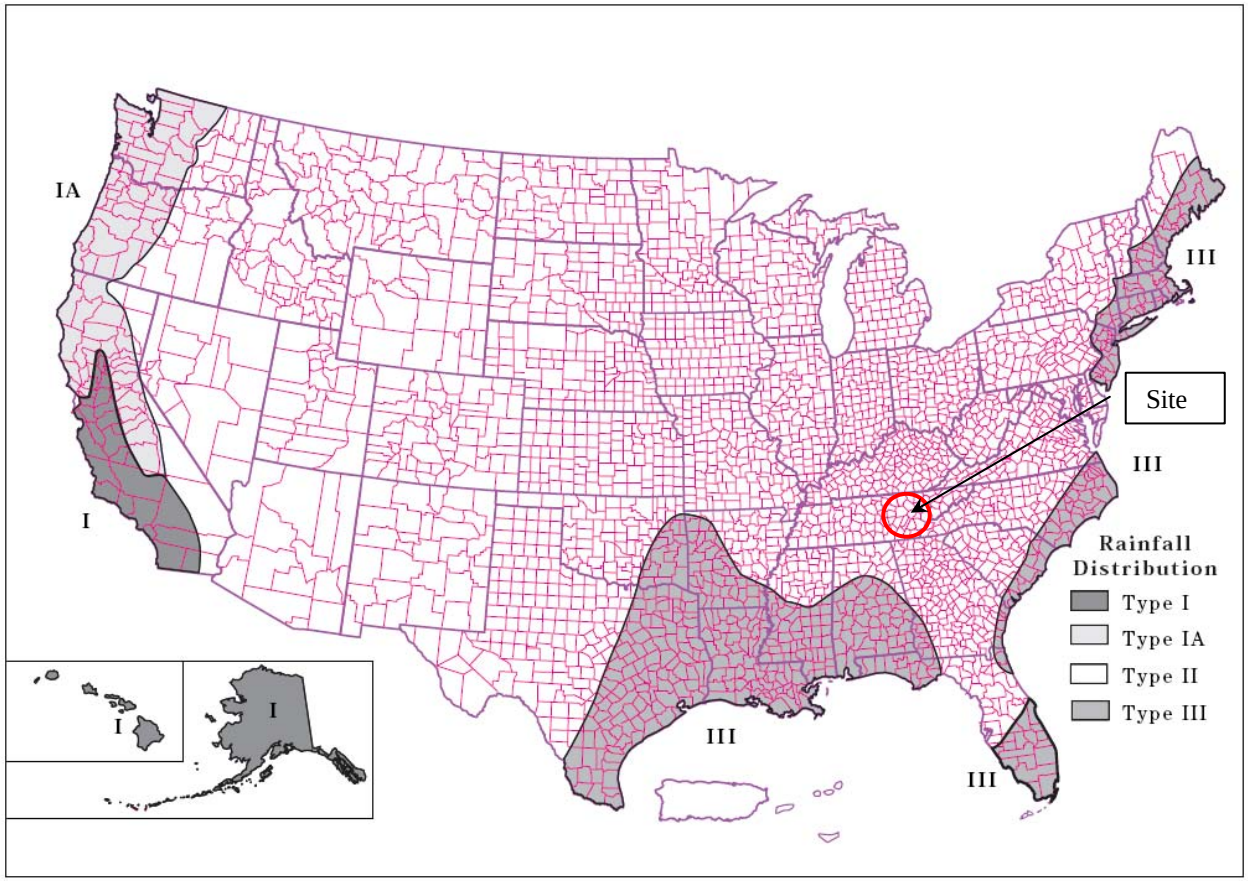
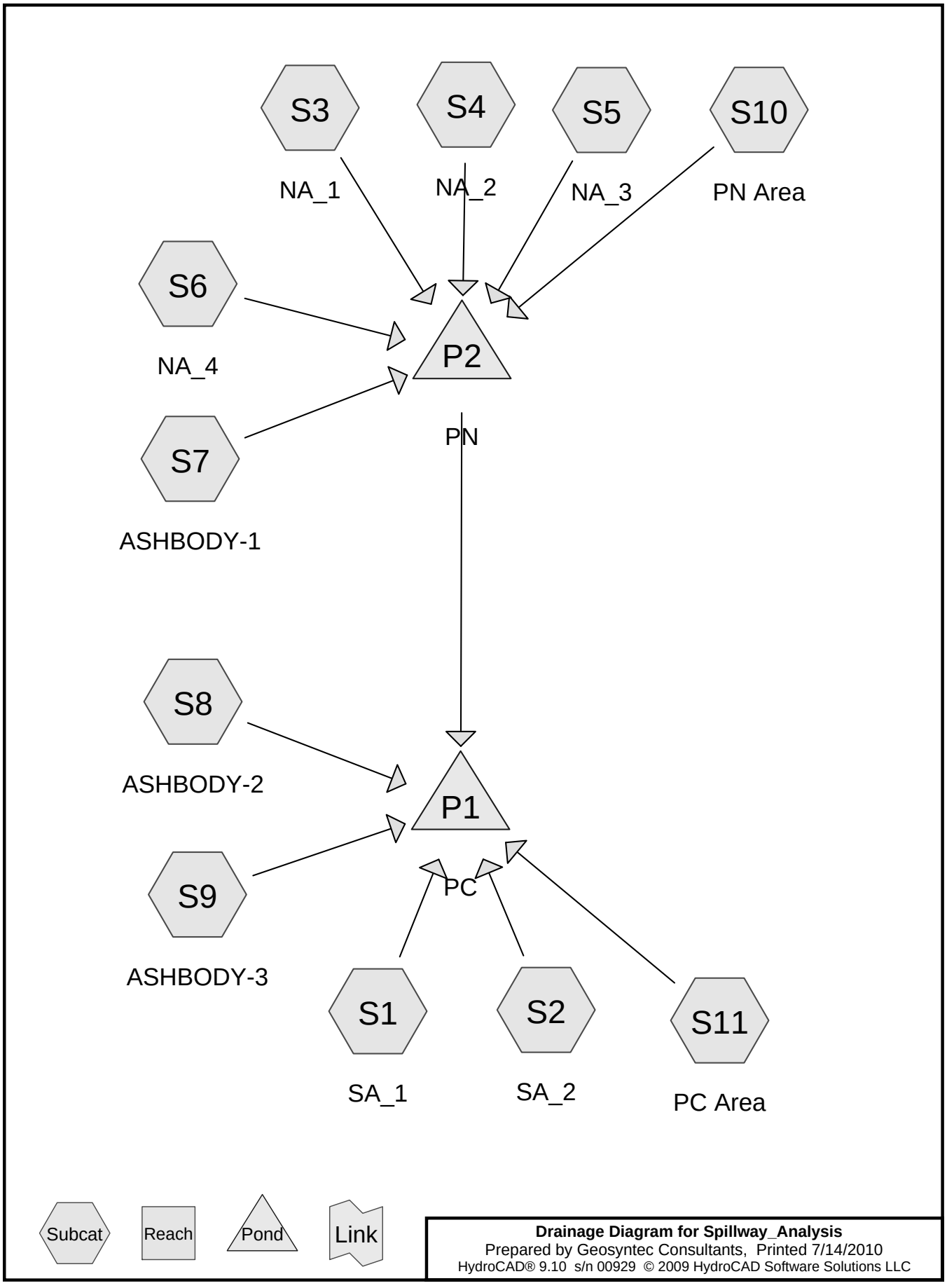
Attachment 7 – Rainfall Distribution

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Attachment 8 – Nodal Network Diagram



Drainage Diagram for Spillway_Analysis
Prepared by Geosyntec Consultants, Printed 7/14/2010

Attachment 9 – Computer Modeling

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
800.000	58	Composite CN (S2, S3)
84.000	59	Composite CN (S5)
794.000	61	Composite CN (S4, S6)
882.000	66	Composite CN (S1)
165.500	91	Newly Graded Areas, HSG C (Silt) (S7, S8, S9)
67.697	100	Pond (S10, S11)
2,793.197		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
165.500	HSG C	S7, S8, S9
0.000	HSG D	
2,627.697	Other	S1, S10, S11, S2, S3, S4, S5, S6
2,793.197		**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Fill (inches)
1	P1	736.50	736.00	115.0	0.0043	0.011	58.8	0.0	0.0
2	P2	747.10	745.00	68.0	0.0309	0.030	48.0	0.0	0.0
3	P2	745.00	745.00	66.0	0.0000	0.030	48.0	0.0	0.0
4	P2	745.30	745.00	66.0	0.0045	0.030	48.0	0.0	0.0
5	P2	738.50	738.00	137.0	0.0036	0.011	58.8	0.0	0.0

Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment S1: SA_1 Runoff Area=882.000 ac 0.00% Impervious Runoff Depth=3.02"
Flow Length=12,641' Slope=0.0146 '/' Tc=348.7 min CN=66 Runoff=361.54 cfs 222.325 af

Subcatchment S10: PN Area Runoff Area=30.718 ac 100.00% Impervious Runoff Depth=6.77"
Tc=0.0 min CN=100 Runoff=334.28 cfs 17.330 af

Subcatchment S11: PC Area Runoff Area=36.979 ac 100.00% Impervious Runoff Depth=6.77"
Tc=0.0 min CN=100 Runoff=402.41 cfs 20.862 af

Subcatchment S2: SA_2 Runoff Area=624.000 ac 0.00% Impervious Runoff Depth=2.25"
Flow Length=8,746' Slope=0.0308 '/' Tc=166.1 min CN=58 Runoff=321.02 cfs 117.223 af

Subcatchment S3: NA_1 Runoff Area=176.000 ac 0.00% Impervious Runoff Depth=2.25"
Flow Length=3,358' Slope=0.0259 '/' Tc=69.6 min CN=58 Runoff=174.27 cfs 33.063 af

Subcatchment S4: NA_2 Runoff Area=646.000 ac 0.00% Impervious Runoff Depth=2.54"
Flow Length=6,729' Slope=0.0036 '/' Tc=267.0 min CN=61 Runoff=262.49 cfs 136.588 af

Subcatchment S5: NA_3 Runoff Area=84.000 ac 0.00% Impervious Runoff Depth=2.35"
Flow Length=1,252' Slope=0.0935 '/' Tc=9.7 min CN=59 Runoff=296.97 cfs 16.434 af

Subcatchment S6: NA_4 Runoff Area=148.000 ac 0.00% Impervious Runoff Depth=2.54"
Flow Length=4,599' Slope=0.0398 '/' Tc=54.9 min CN=61 Runoff=202.73 cfs 31.293 af

Subcatchment S7: ASHBODY-1 Runoff Area=24.400 ac 0.00% Impervious Runoff Depth=5.71"
Flow Length=1,058' Slope=0.0076 '/' Tc=20.2 min CN=91 Runoff=144.86 cfs 11.616 af

Subcatchment S8: ASHBODY-2 Runoff Area=127.500 ac 0.00% Impervious Runoff Depth=5.71"
Flow Length=2,755' Slope=0.0247 '/' Tc=29.2 min CN=91 Runoff=612.24 cfs 60.696 af

Subcatchment S9: ASHBODY-3 Runoff Area=13.600 ac 0.00% Impervious Runoff Depth=5.71"
Flow Length=647' Slope=0.0680 '/' Tc=4.1 min CN=91 Runoff=130.41 cfs 6.474 af

Pond P1: PC Peak Elev=744.29' Storage=20.298 af Inflow=914.78 cfs 673.904 af
Primary=726.67 cfs 636.826 af Secondary=111.55 cfs 37.077 af Tertiary=0.00 cfs 0.000 af Outflow=838.22 cfs 673.904 af

Pond P2: PN Peak Elev=744.88' Storage=24.334 af Inflow=567.61 cfs 246.324 af
Outflow=305.73 cfs 246.324 af

Total Runoff Area = 2,793.197 ac Runoff Volume = 673.904 af Average Runoff Depth = 2.90"
97.58% Pervious = 2,725.500 ac 2.42% Impervious = 67.697 ac

Summary for Subcatchment S1: SA_1

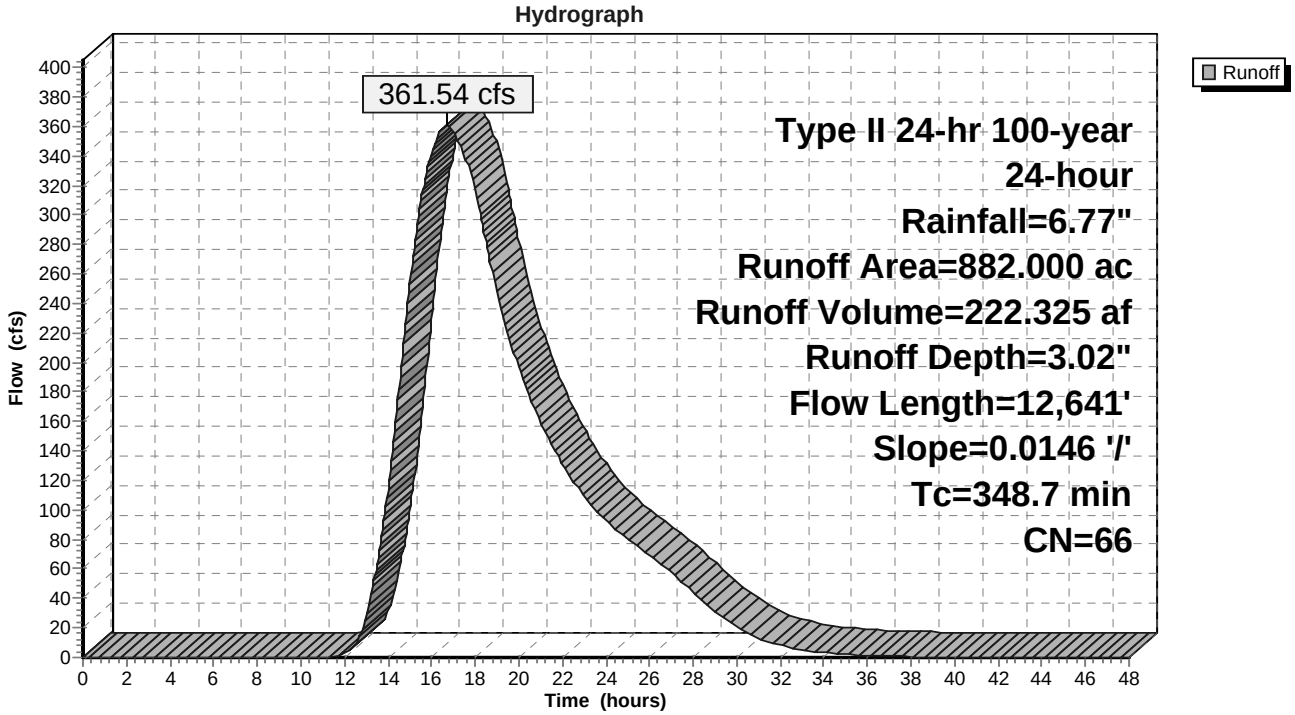
Runoff = 361.54 cfs @ 16.66 hrs, Volume= 222.325 af, Depth= 3.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	882.000	66	Composite CN
	882.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
348.7	12,641	0.0146	0.60		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S1: SA_1



Summary for Subcatchment S10: PN Area

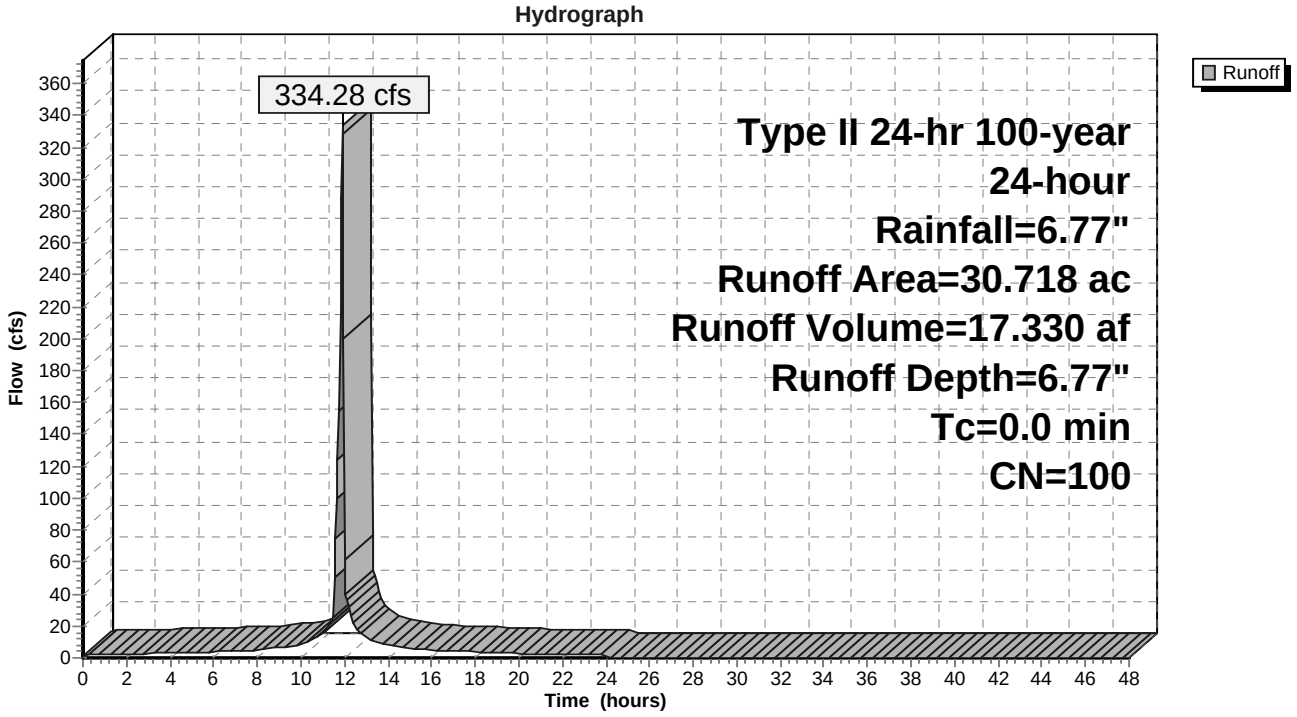
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 334.28 cfs @ 11.89 hrs, Volume= 17.330 af, Depth= 6.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	30.718	100	Pond
	30.718		100.00% Impervious Area

Subcatchment S10: PN Area



Summary for Subcatchment S11: PC Area

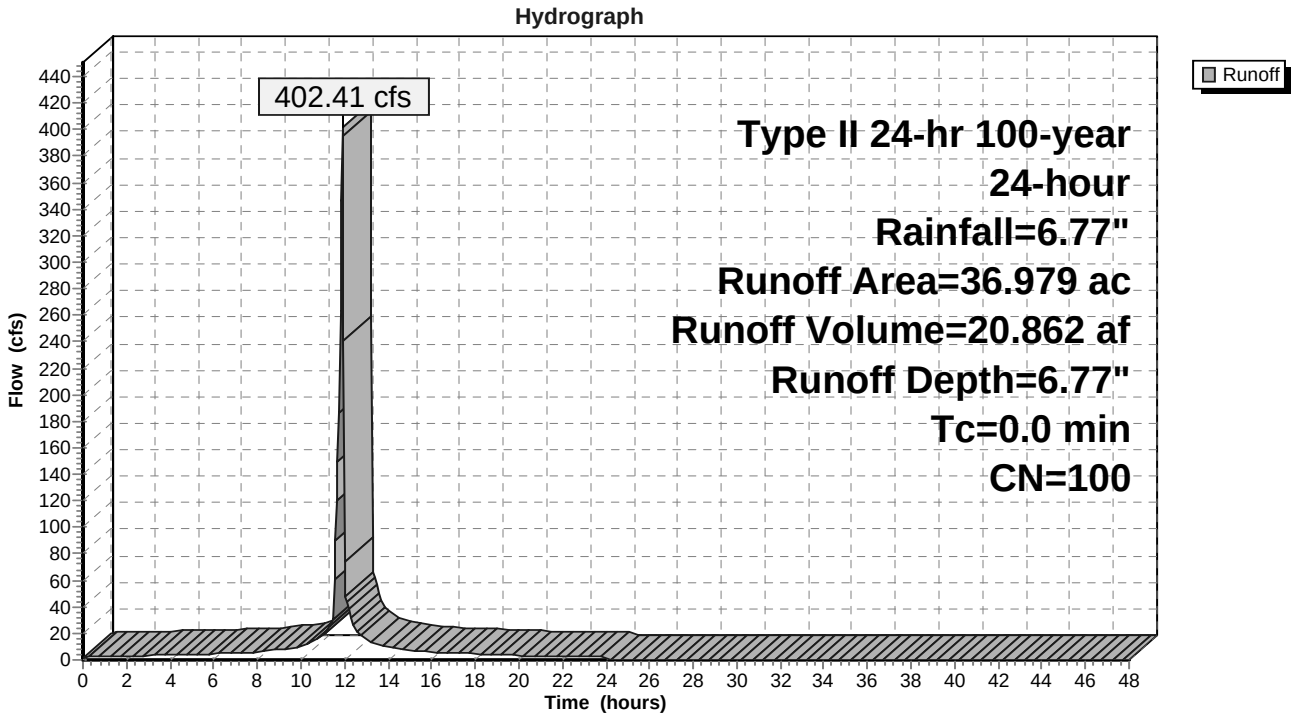
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 402.41 cfs @ 11.89 hrs, Volume= 20.862 af, Depth= 6.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	36.979	100	Pond
	36.979		100.00% Impervious Area

Subcatchment S11: PC Area



Summary for Subcatchment S2: SA_2

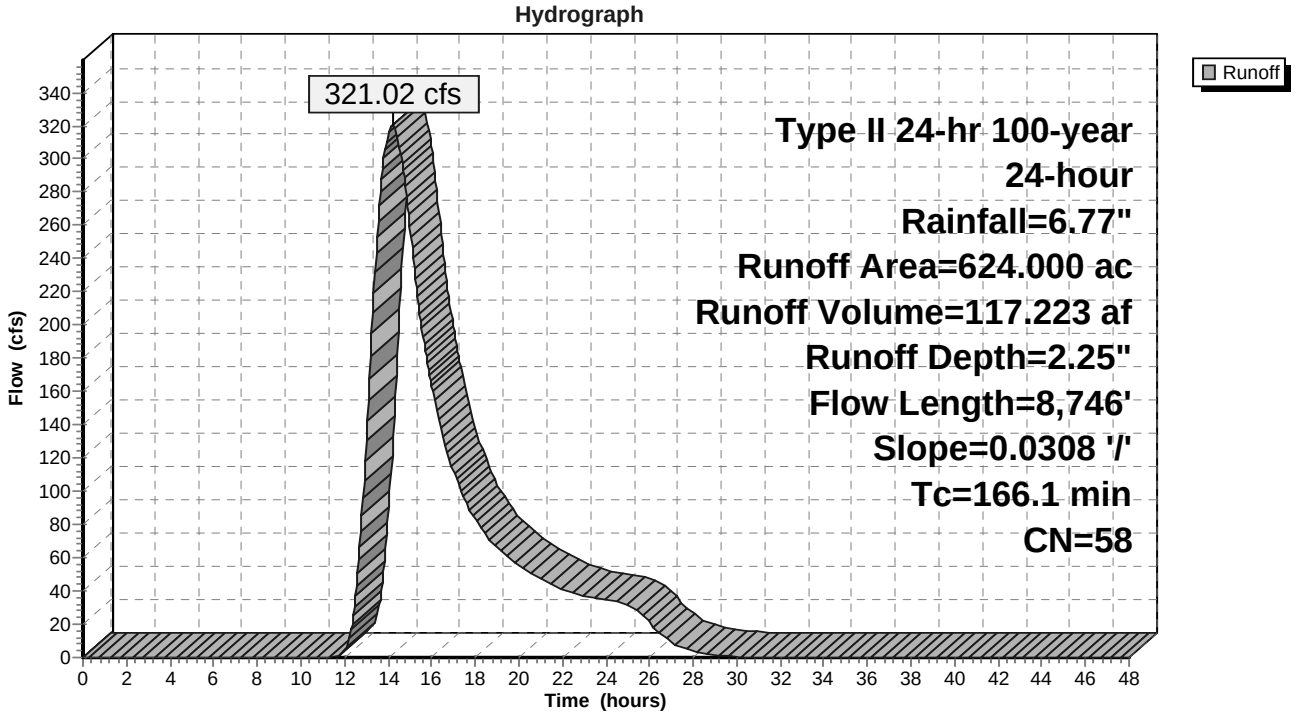
Runoff = 321.02 cfs @ 14.20 hrs, Volume= 117.223 af, Depth= 2.25"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	624.000	58	Composite CN
	624.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
166.1	8,746	0.0308	0.88		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S2: SA_2



Summary for Subcatchment S3: NA_1

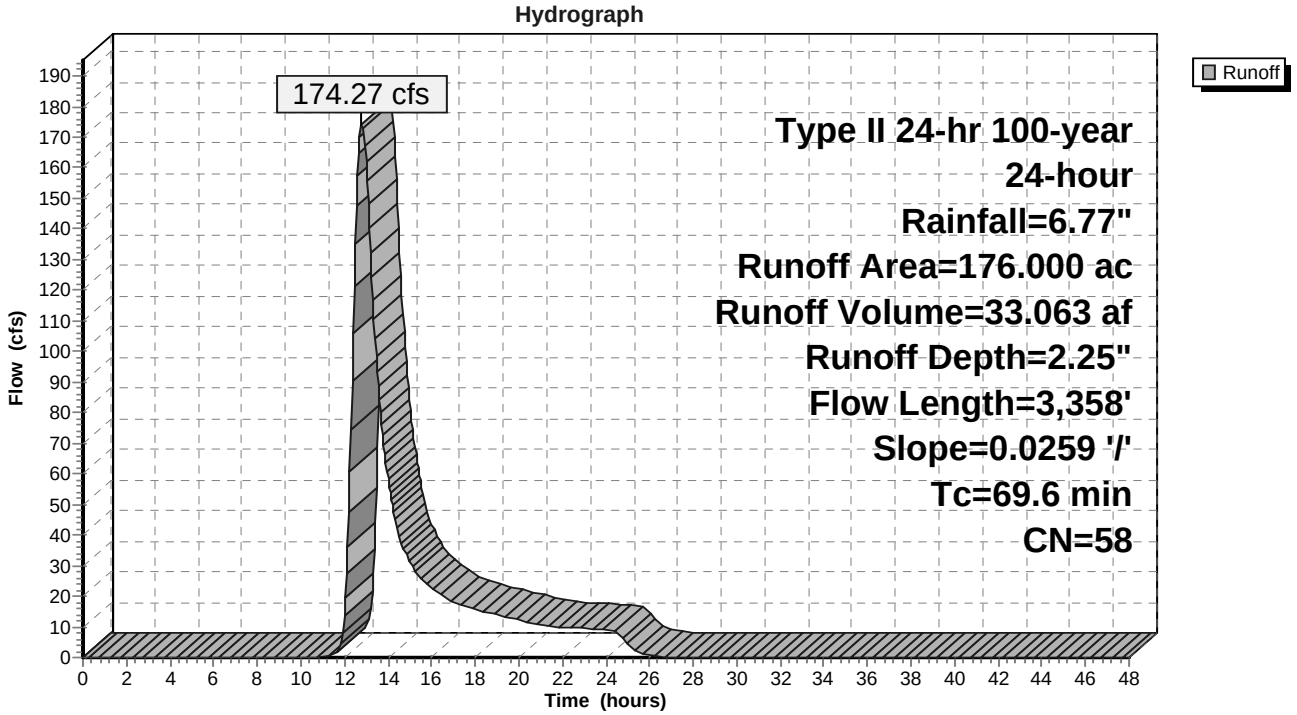
Runoff = 174.27 cfs @ 12.79 hrs, Volume= 33.063 af, Depth= 2.25"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	176.000	58	Composite CN
	176.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
69.6	3,358	0.0259	0.80		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S3: NA_1



Summary for Subcatchment S4: NA_2

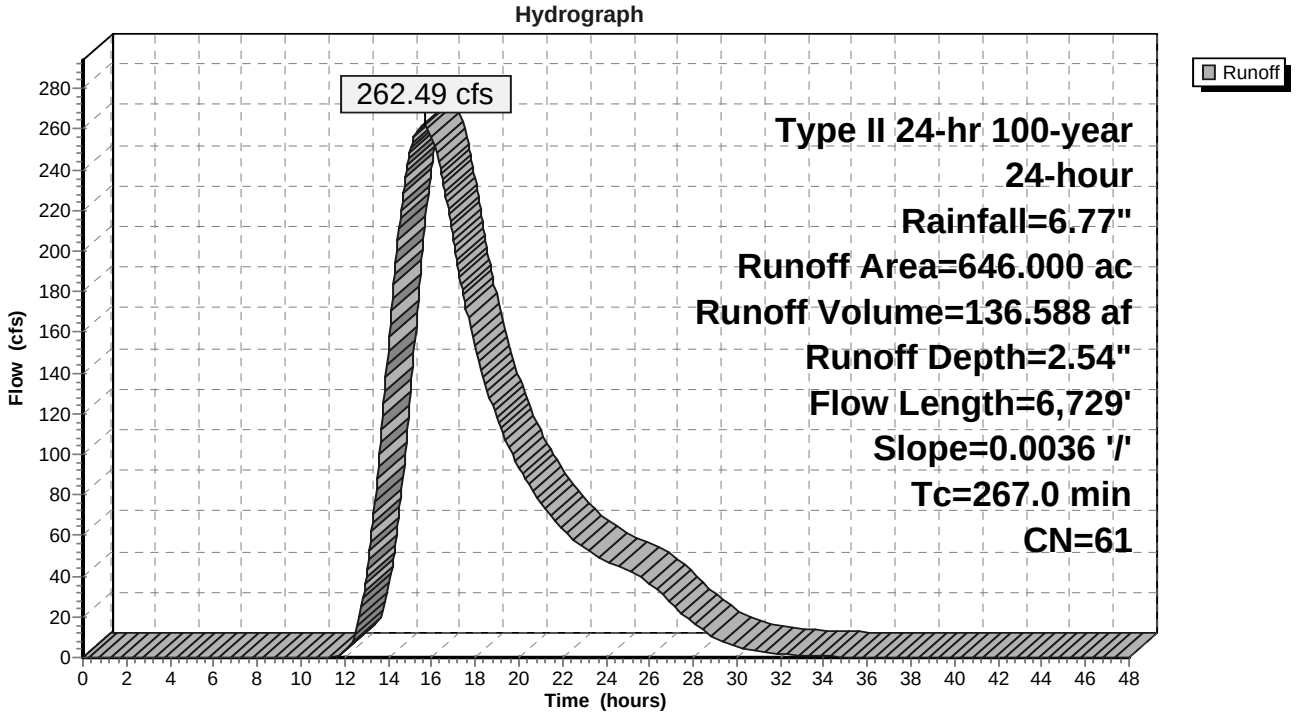
Runoff = 262.49 cfs @ 15.69 hrs, Volume= 136.588 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	646.000	61	Composite CN
	646.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
267.0	6,729	0.0036	0.42		**Shallow Concentrated Flow, Overland FLow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S4: NA_2



Summary for Subcatchment S5: NA_3

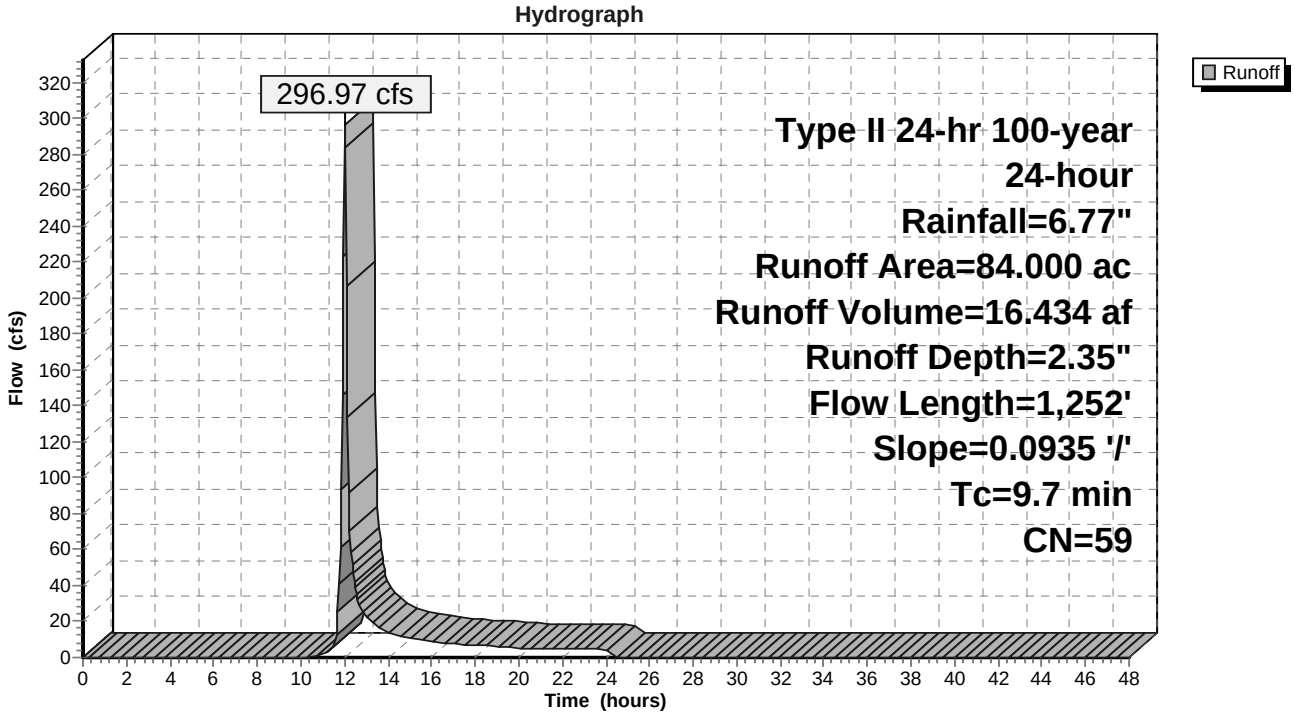
Runoff = 296.97 cfs @ 12.02 hrs, Volume= 16.434 af, Depth= 2.35"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	84.000	59	Composite CN
	84.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.7	1,252	0.0935	2.14		**Shallow Concentrated Flow, Overland Flow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S5: NA_3



Summary for Subcatchment S6: NA_4

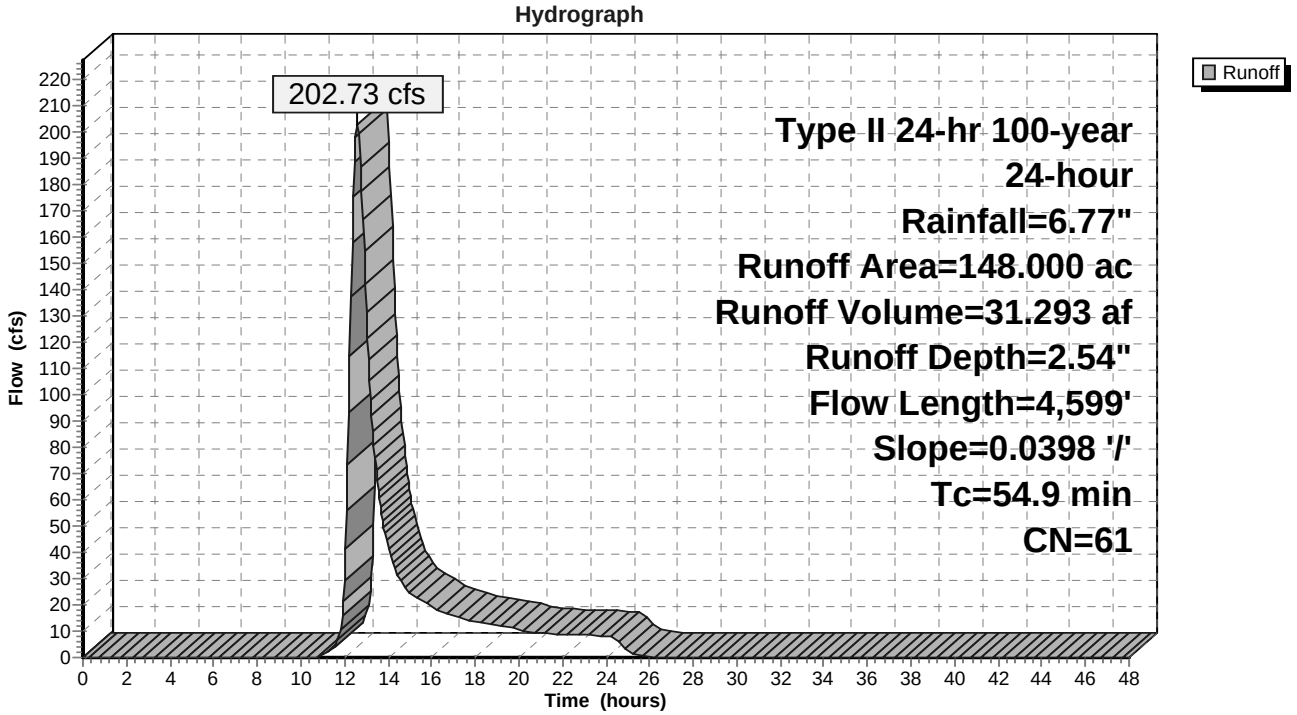
Runoff = 202.73 cfs @ 12.59 hrs, Volume= 31.293 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	148.000	61	Composite CN
	148.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
54.9	4,599	0.0398	1.40		**Shallow Concentrated Flow, Overland Flow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S6: NA_4



Summary for Subcatchment S7: ASHBODY-1

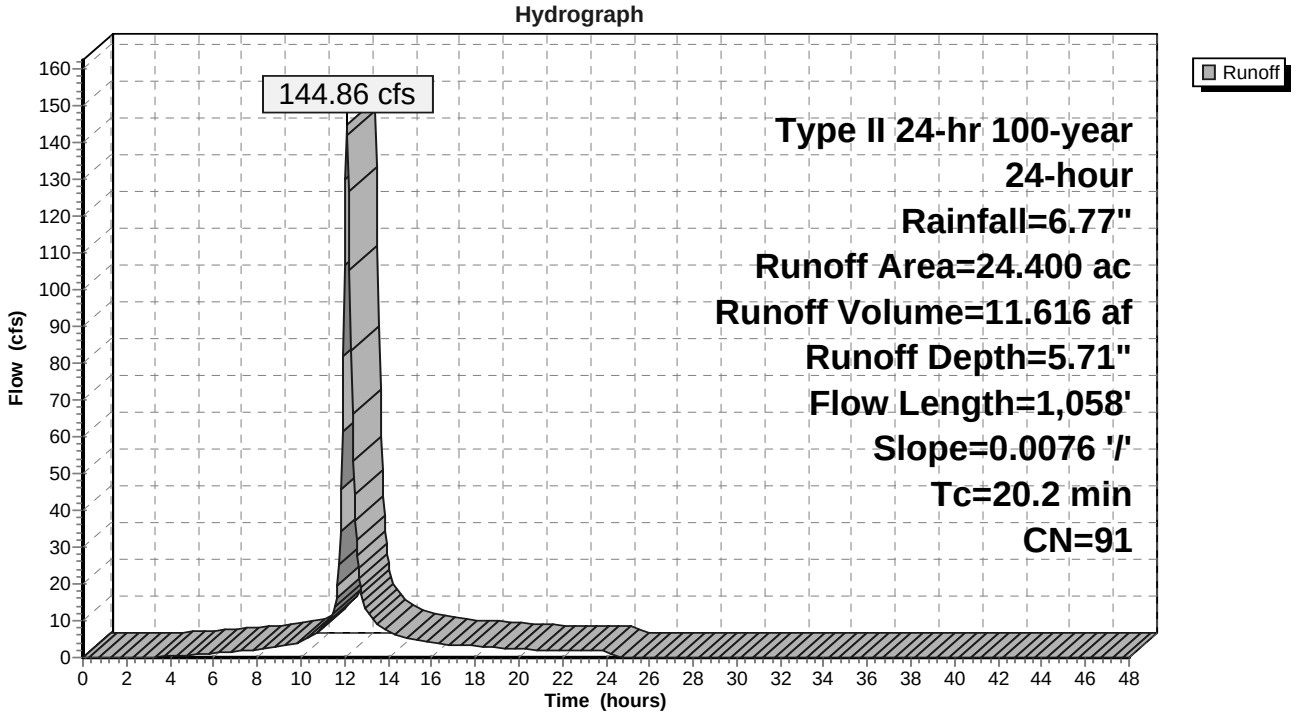
Runoff = 144.86 cfs @ 12.12 hrs, Volume= 11.616 af, Depth= 5.71"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	24.400	91	Newly Graded Areas, HSG C (Silt)
	24.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.2	1,058	0.0076	0.87		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S7: ASHBODY-1



Summary for Subcatchment S8: ASHBODY-2

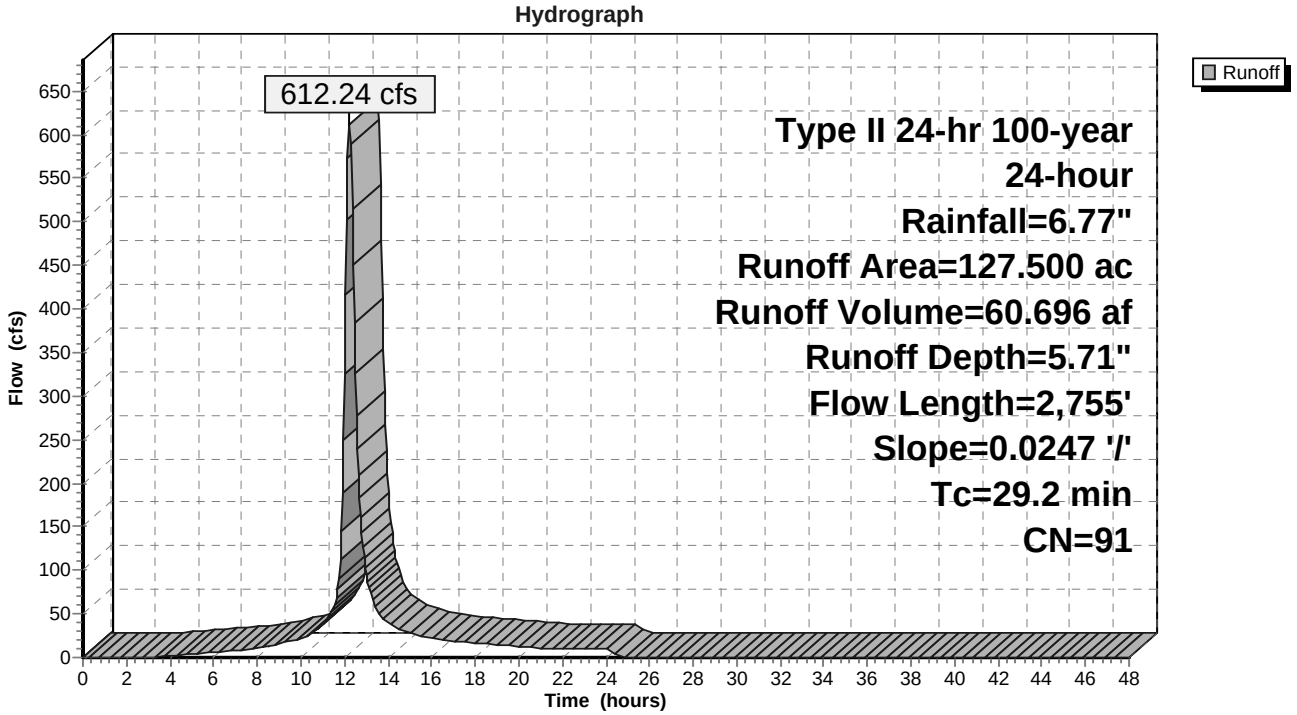
Runoff = 612.24 cfs @ 12.22 hrs, Volume= 60.696 af, Depth= 5.71"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	127.500	91	Newly Graded Areas, HSG C (Silt)
	127.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.2	2,755	0.0247	1.57		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S8: ASHBODY-2



Summary for Subcatchment S9: ASHBODY-3

[49] Hint: Tc<2dt may require smaller dt

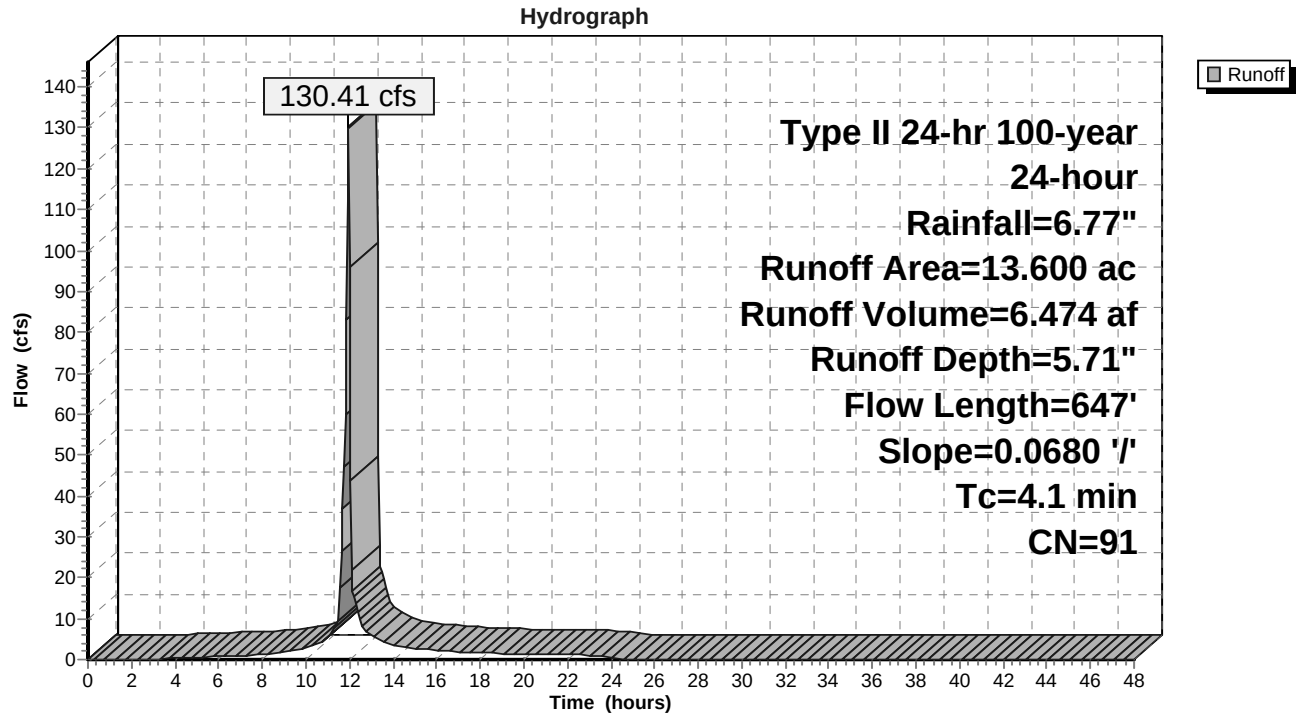
Runoff = 130.41 cfs @ 11.94 hrs, Volume= 6.474 af, Depth= 5.71"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year, 24-hour Rainfall=6.77"

	Area (ac)	CN	Description
*	13.600	91	Newly Graded Areas, HSG C (Silt)
	13.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	647	0.0680	2.61		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S9: ASHBODY-3



Summary for Pond P1: PC

[81] Warning: Exceeded Pond P2 by 0.25' @ 23.35 hrs

Inflow Area = 2,793.197 ac, 2.42% Impervious, Inflow Depth = 2.90" for 100-year, 24-hour event
Inflow = 914.78 cfs @ 12.23 hrs, Volume= 673.904 af
Outflow = 838.22 cfs @ 16.12 hrs, Volume= 673.904 af, Atten= 8%, Lag= 233.4 min
Primary = 726.67 cfs @ 16.12 hrs, Volume= 636.826 af
Secondary = 111.55 cfs @ 16.12 hrs, Volume= 37.077 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 744.29' @ 16.12 hrs Surf.Area= 0.000 ac Storage= 20.298 af

Plug-Flow detention time= 11.5 min calculated for 673.902 af (100% of inflow)
Center-of-Mass det. time= 11.5 min (1,044.8 - 1,033.3)

Volume	Invert	Avail.Storage	Storage Description
#1	741.00'	158.188 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
741.00	0.000
742.00	2.013
744.00	15.695
746.00	47.335
748.00	93.924
750.00	158.188

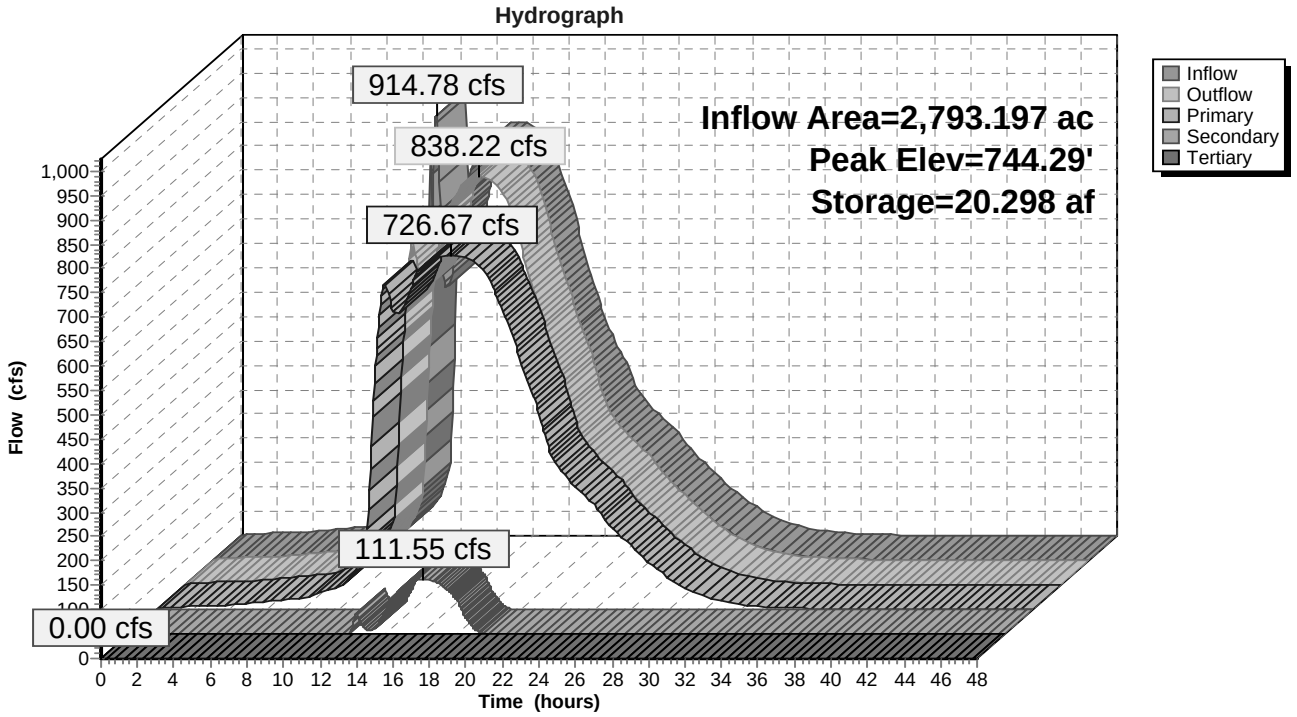
Device	Routing	Invert	Outlet Devices
#1	Secondary	743.00'	**60.0" Horiz. Overflow Pipe 1** C= 0.600 Limited to weir flow at low heads
#2	Secondary	743.50'	**60.0" Horiz. Overflow Pipe 2** C= 0.600 Limited to weir flow at low heads
#3	Primary	736.50'	**58.8" Round O_CU X 5.00** L= 115.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 736.50' / 736.00' S= 0.0043 '/' Cc= 0.900 n= 0.011 PVC, smooth interior
#4	Tertiary	746.00'	**144.0 deg x 4.4' long x 4.00' rise Spillway** C= 2.57

Primary OutFlow Max=726.69 cfs @ 16.12 hrs HW=744.29' TW=741.00' (Fixed TW Elev= 741.00')
└─**3=O_CU** (Inlet Controls 726.69 cfs @ 7.71 fps)

Secondary OutFlow Max=111.47 cfs @ 16.12 hrs HW=744.29' TW=741.00' (Fixed TW Elev= 741.00')
├─**1=Overflow Pipe 1** (Weir Controls 75.34 cfs @ 3.72 fps)
└─**2=Overflow Pipe 2** (Weir Controls 36.13 cfs @ 2.91 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=741.00' TW=741.00' (Fixed TW Elev= 741.00')
└─**4=Spillway** (Controls 0.00 cfs)

Pond P1: PC


Hydrograph
914.78 cfs
838.22 cfs
726.67 cfs
111.55 cfs
0.00 cfs
Inflow Area=2,793.197 ac
Peak Elev=744.29'
Storage=20.298 af
Inflow
Outflow
Primary
Secondary
Tertiary
Flow (cfs)
Time (hours)

Summary for Pond P2: PN

Inflow Area = 1,109.118 ac, 2.77% Impervious, Inflow Depth = 2.67" for 100-year, 24-hour event
Inflow = 567.61 cfs @ 11.92 hrs, Volume= 246.324 af
Outflow = 305.73 cfs @ 16.20 hrs, Volume= 246.324 af, Atten= 46%, Lag= 257.2 min
Primary = 305.73 cfs @ 16.20 hrs, Volume= 246.324 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 744.88' @ 16.20 hrs Surf.Area= 0.000 ac Storage= 24.334 af

Plug-Flow detention time= 38.2 min calculated for 246.066 af (100% of inflow)
Center-of-Mass det. time= 38.2 min (1,025.2 - 987.1)

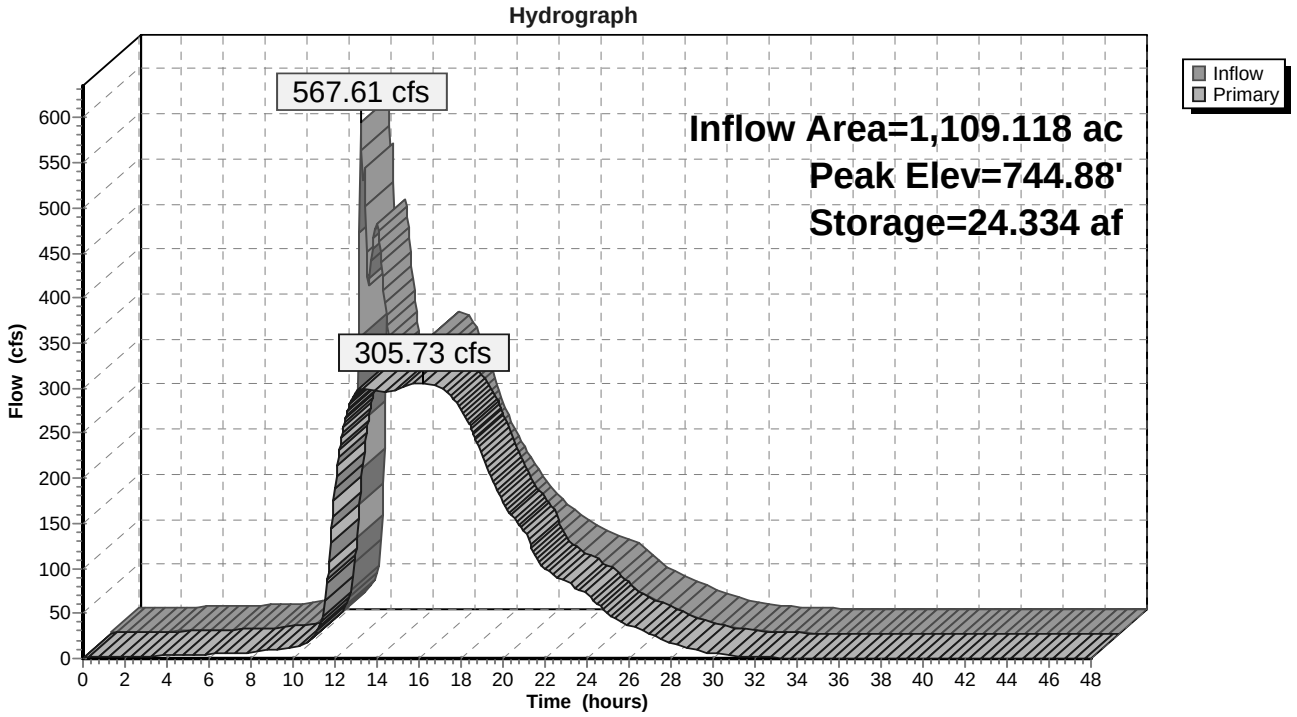
Volume	Invert	Avail.Storage	Storage Description
#1	741.00'	101.017 af	**Pond North** Listed below

Elevation (feet)	Cum.Store (acre-feet)
741.00	0.000
742.00	1.977
744.00	14.791
746.00	36.569
748.00	65.872
750.00	101.017

Device	Routing	Invert	Outlet Devices
#1	Primary	747.10'	**48.0" Round Culvert_1** L= 68.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 747.10' / 745.00' S= 0.0309 '/' Cc= 0.900 n= 0.030 Corrugated metal
#2	Primary	745.00'	**48.0" Round Culvert_2** L= 66.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 745.00' / 745.00' S= 0.0000 '/' Cc= 0.900 n= 0.030 Corrugated metal
#3	Primary	745.30'	**48.0" Round Culvert_3** L= 66.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 745.30' / 745.00' S= 0.0045 '/' Cc= 0.900 n= 0.030 Corrugated metal
#4	Primary	738.50'	**58.8" Round NED_CU X 2.00** L= 137.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 738.50' / 738.00' S= 0.0036 '/' Cc= 0.900 n= 0.011 PVC, smooth interior

Primary OutFlow Max=305.86 cfs @ 16.20 hrs HW=744.88' (Free Discharge)
- **1=Culvert_1** (Controls 0.00 cfs)
- **2=Culvert_2** (Controls 0.00 cfs)
- **3=Culvert_3** (Controls 0.00 cfs)
- **4=NED_CU** (Barrel Controls 305.86 cfs @ 8.16 fps)

Pond P2: PN


Hydrograph
567.61 cfs
305.73 cfs
Inflow Area=1,109.118 ac
Peak Elev=744.88'
Storage=24.334 af
Inflow
Primary
Flow (cfs)
0
50
100
150
200
250
300
350
400
450
500
550
600
Time (hours)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48

Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment S1: SA_1 Runoff Area=882.000 ac 0.00% Impervious Runoff Depth=4.26"
Flow Length=12,641' Slope=0.0146 '/' Tc=348.7 min CN=66 Runoff=517.14 cfs 313.329 af

Subcatchment S10: PN Area Runoff Area=30.718 ac 100.00% Impervious Runoff Depth=8.31"
Tc=0.0 min CN=100 Runoff=410.31 cfs 21.272 af

Subcatchment S11: PC Area Runoff Area=36.979 ac 100.00% Impervious Runoff Depth=8.31"
Tc=0.0 min CN=100 Runoff=493.95 cfs 25.608 af

Subcatchment S2: SA_2 Runoff Area=624.000 ac 0.00% Impervious Runoff Depth=3.34"
Flow Length=8,746' Slope=0.0308 '/' Tc=166.1 min CN=58 Runoff=492.19 cfs 173.602 af

Subcatchment S3: NA_1 Runoff Area=176.000 ac 0.00% Impervious Runoff Depth=3.34"
Flow Length=3,358' Slope=0.0259 '/' Tc=69.6 min CN=58 Runoff=269.30 cfs 48.965 af

Subcatchment S4: NA_2 Runoff Area=646.000 ac 0.00% Impervious Runoff Depth=3.68"
Flow Length=6,729' Slope=0.0036 '/' Tc=267.0 min CN=61 Runoff=389.53 cfs 198.252 af

Subcatchment S5: NA_3 Runoff Area=84.000 ac 0.00% Impervious Runoff Depth=3.45"
Flow Length=1,252' Slope=0.0935 '/' Tc=9.7 min CN=59 Runoff=442.92 cfs 24.170 af

Subcatchment S6: NA_4 Runoff Area=148.000 ac 0.00% Impervious Runoff Depth=3.68"
Flow Length=4,599' Slope=0.0398 '/' Tc=54.9 min CN=61 Runoff=302.71 cfs 45.420 af

Subcatchment S7: ASHBODY-1 Runoff Area=24.400 ac 0.00% Impervious Runoff Depth=7.23"
Flow Length=1,058' Slope=0.0076 '/' Tc=20.2 min CN=91 Runoff=181.05 cfs 14.702 af

Subcatchment S8: ASHBODY-2 Runoff Area=127.500 ac 0.00% Impervious Runoff Depth=7.23"
Flow Length=2,755' Slope=0.0247 '/' Tc=29.2 min CN=91 Runoff=765.82 cfs 76.826 af

Subcatchment S9: ASHBODY-3 Runoff Area=13.600 ac 0.00% Impervious Runoff Depth=7.23"
Flow Length=647' Slope=0.0680 '/' Tc=4.1 min CN=91 Runoff=162.52 cfs 8.195 af

Pond P1: PC Peak Elev=745.75' Storage=43.375 af Inflow=1,213.38 cfs 950.341 af
mary=873.01 cfs 810.298 af Secondary=298.57 cfs 140.043 af Tertiary=0.00 cfs 0.000 af Outflow=1,171.58 cfs 950.341 af

Pond P2: PN Peak Elev=747.18' Storage=53.802 af Inflow=786.26 cfs 352.781 af
Outflow=427.48 cfs 352.781 af

Total Runoff Area = 2,793.197 ac Runoff Volume = 950.341 af Average Runoff Depth = 4.08"
97.58% Pervious = 2,725.500 ac 2.42% Impervious = 67.697 ac

Summary for Subcatchment S1: SA_1

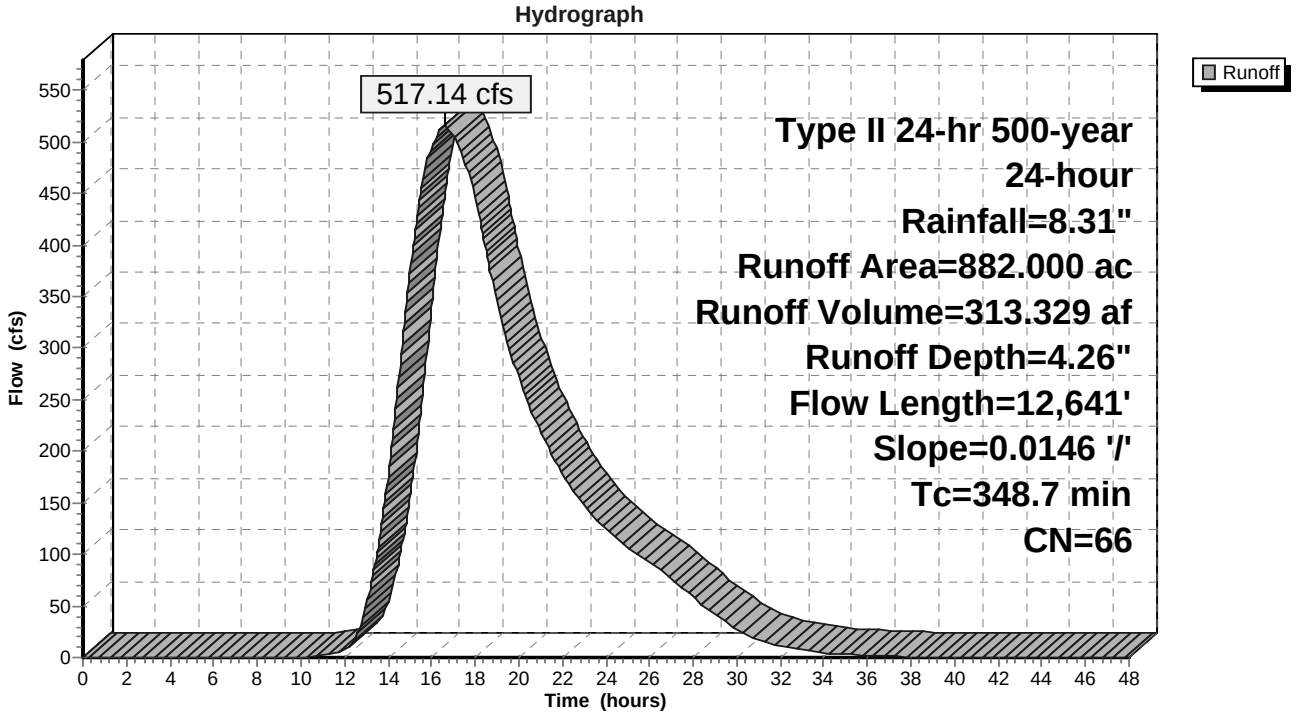
Runoff = 517.14 cfs @ 16.65 hrs, Volume= 313.329 af, Depth= 4.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	882.000	66	Composite CN
	882.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
348.7	12,641	0.0146	0.60		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S1: SA_1



Summary for Subcatchment S10: PN Area

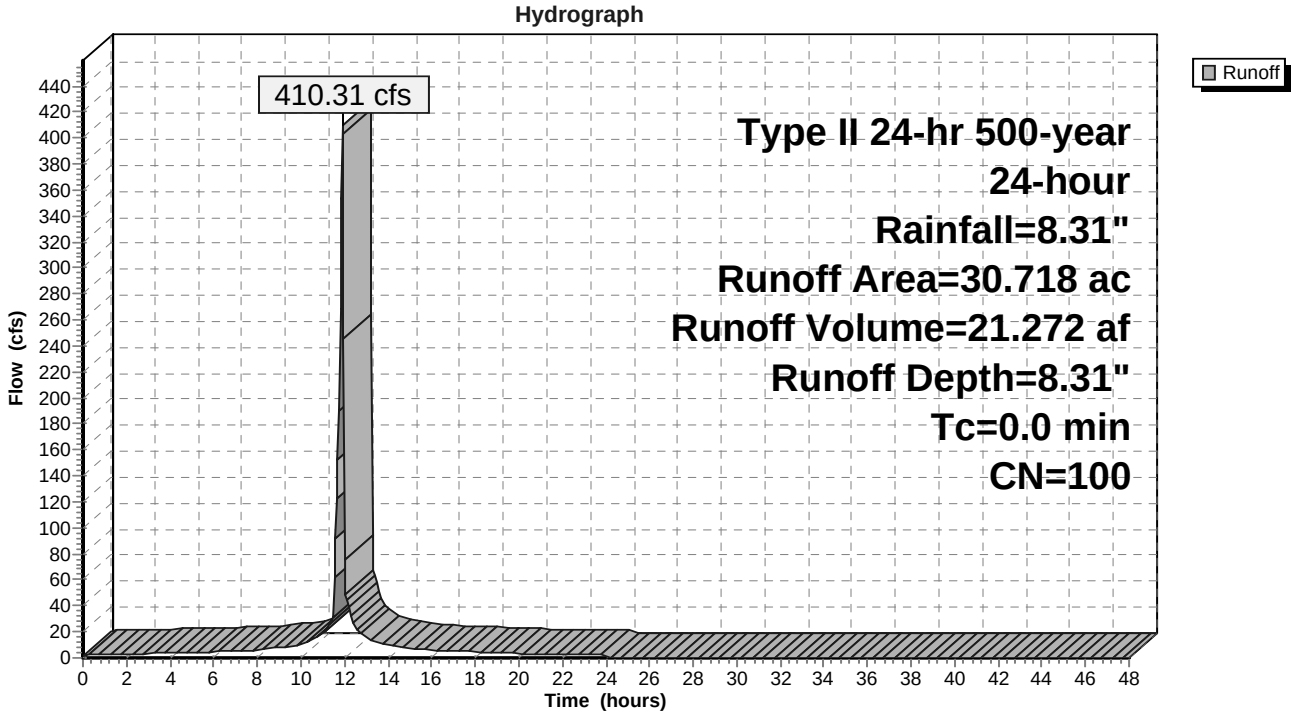
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 410.31 cfs @ 11.89 hrs, Volume= 21.272 af, Depth= 8.31"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	30.718	100	Pond
	30.718		100.00% Impervious Area

Subcatchment S10: PN Area



Summary for Subcatchment S11: PC Area

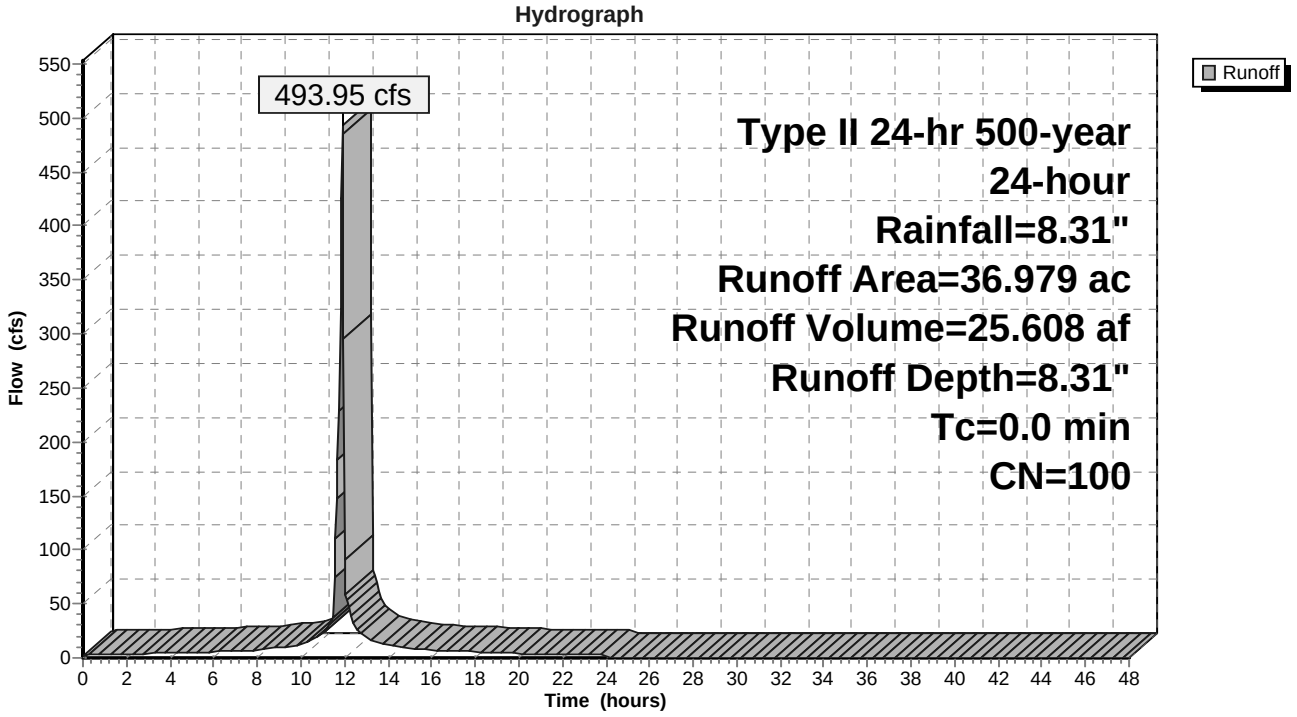
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 493.95 cfs @ 11.89 hrs, Volume= 25.608 af, Depth= 8.31"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	36.979	100	Pond
	36.979		100.00% Impervious Area

Subcatchment S11: PC Area



Summary for Subcatchment S2: SA_2

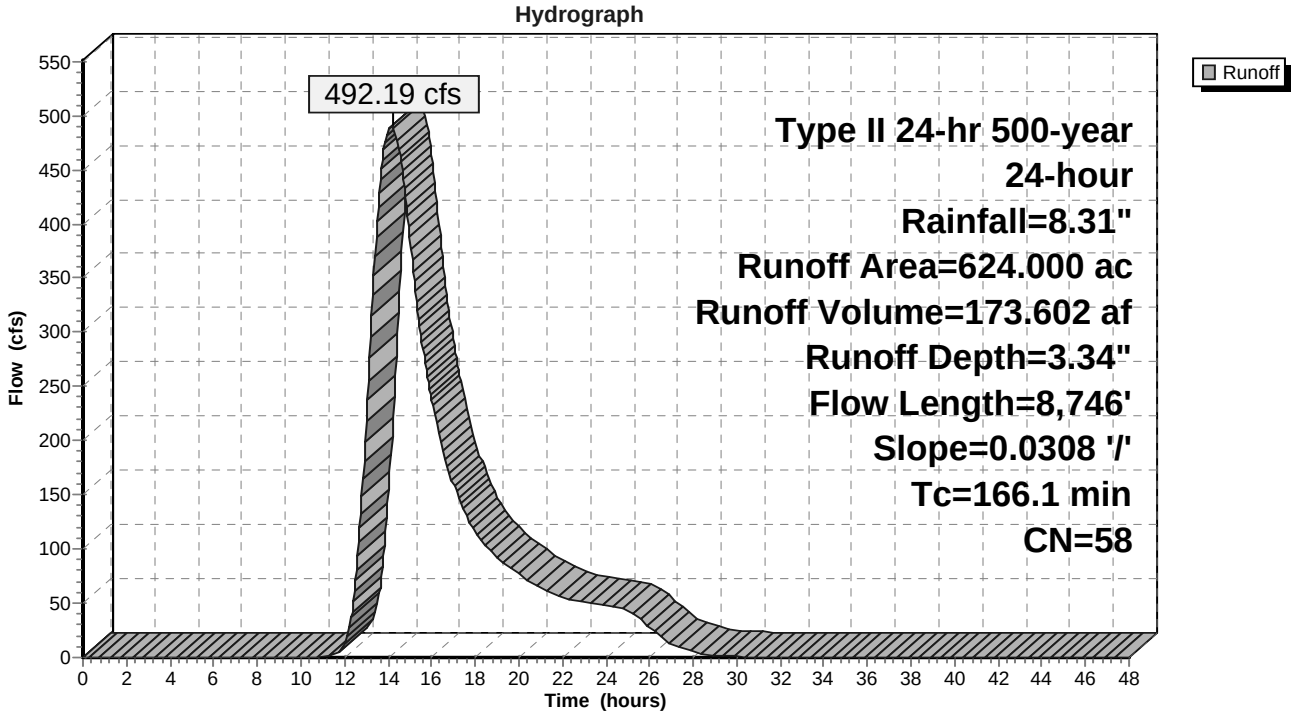
Runoff = 492.19 cfs @ 14.19 hrs, Volume= 173.602 af, Depth= 3.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	624.000	58	Composite CN
	624.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
166.1	8,746	0.0308	0.88		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S2: SA_2



Summary for Subcatchment S3: NA_1

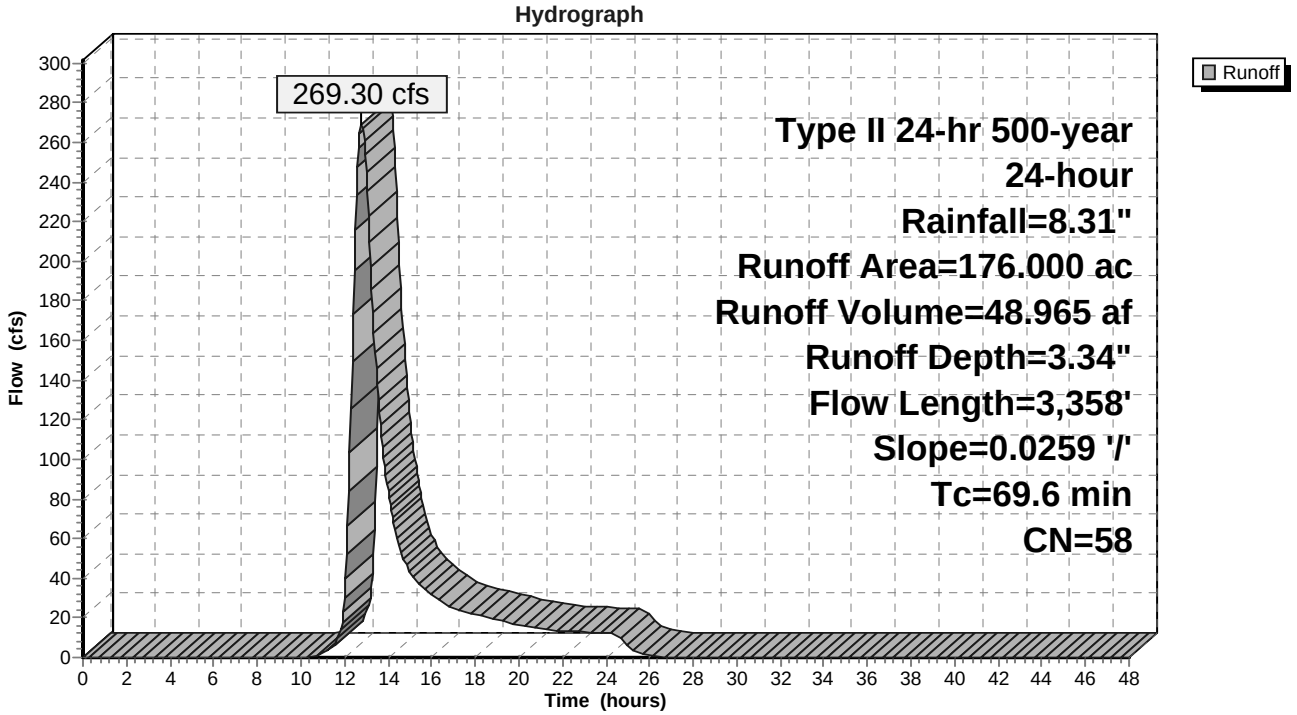
Runoff = 269.30 cfs @ 12.77 hrs, Volume= 48.965 af, Depth= 3.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	176.000	58	Composite CN
	176.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
69.6	3,358	0.0259	0.80		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S3: NA_1



Summary for Subcatchment S4: NA_2

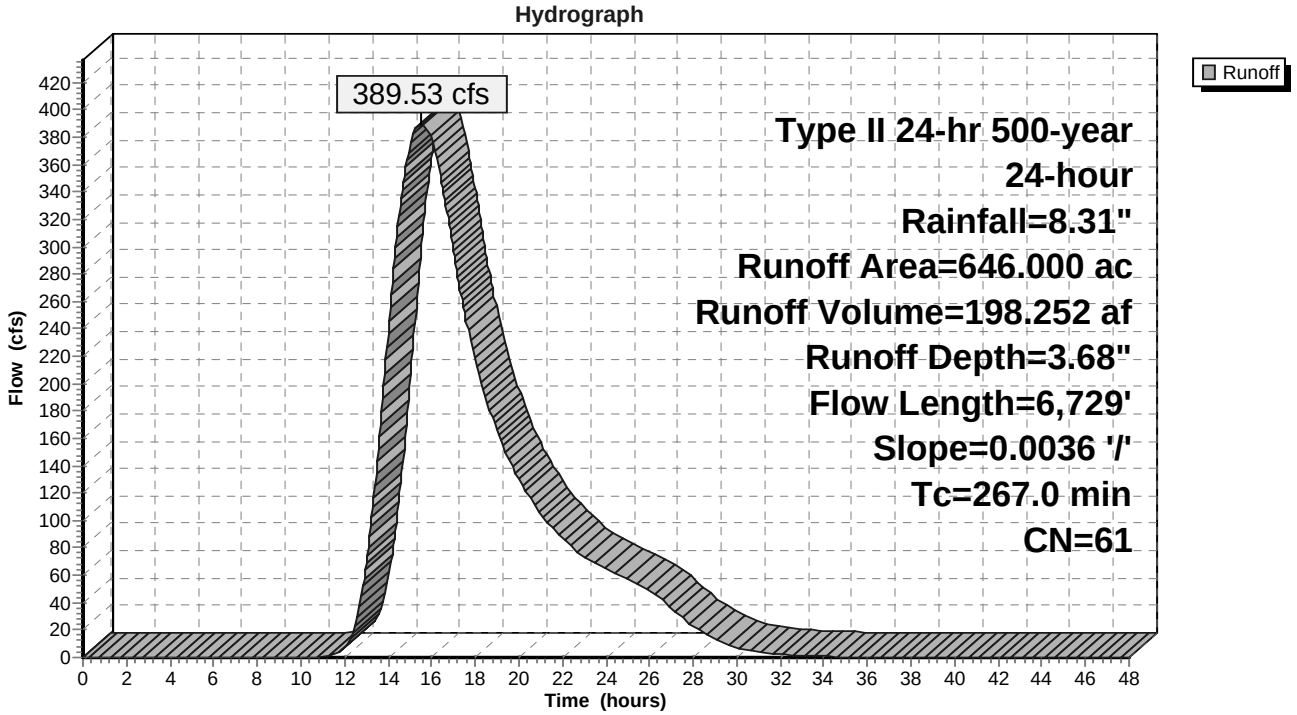
Runoff = 389.53 cfs @ 15.47 hrs, Volume= 198.252 af, Depth= 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	646.000	61	Composite CN
	646.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
267.0	6,729	0.0036	0.42		**Shallow Concentrated Flow, Overland FLow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S4: NA_2



Summary for Subcatchment S5: NA_3

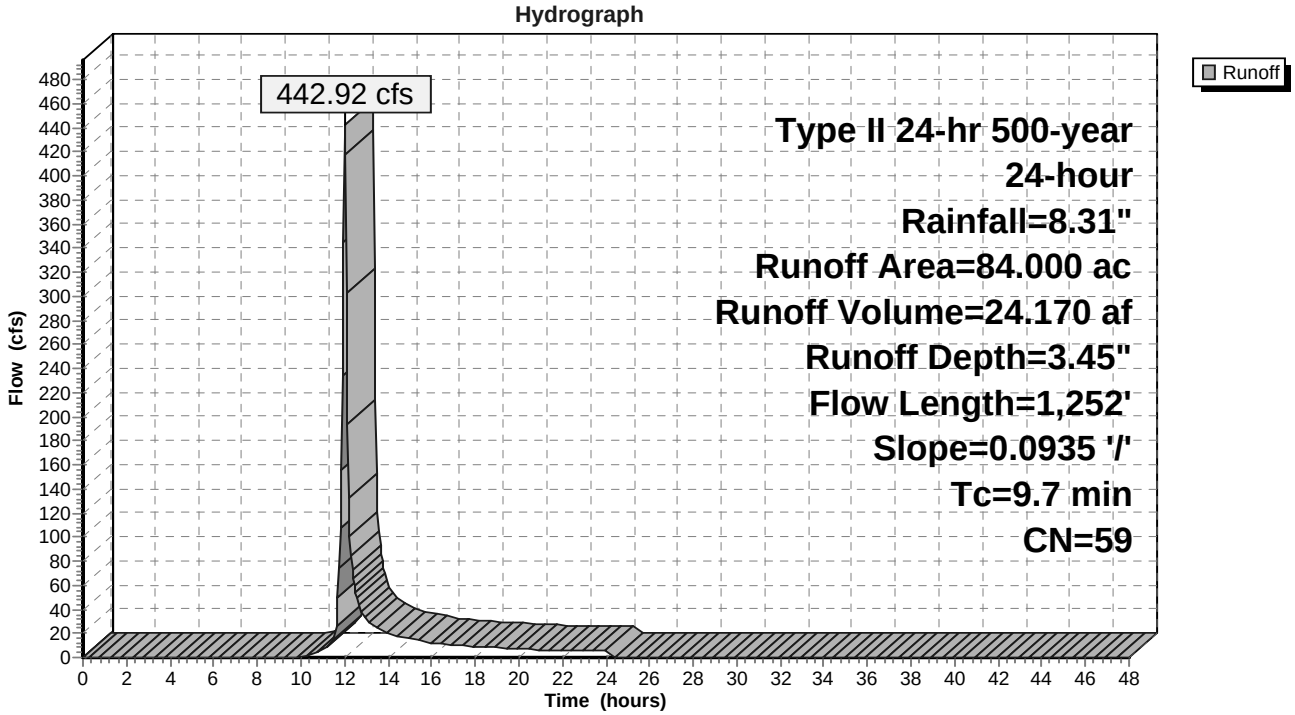
Runoff = 442.92 cfs @ 12.02 hrs, Volume= 24.170 af, Depth= 3.45"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	84.000	59	Composite CN
	84.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.7	1,252	0.0935	2.14		**Shallow Concentrated Flow, Overland Flow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S5: NA_3



Summary for Subcatchment S6: NA_4

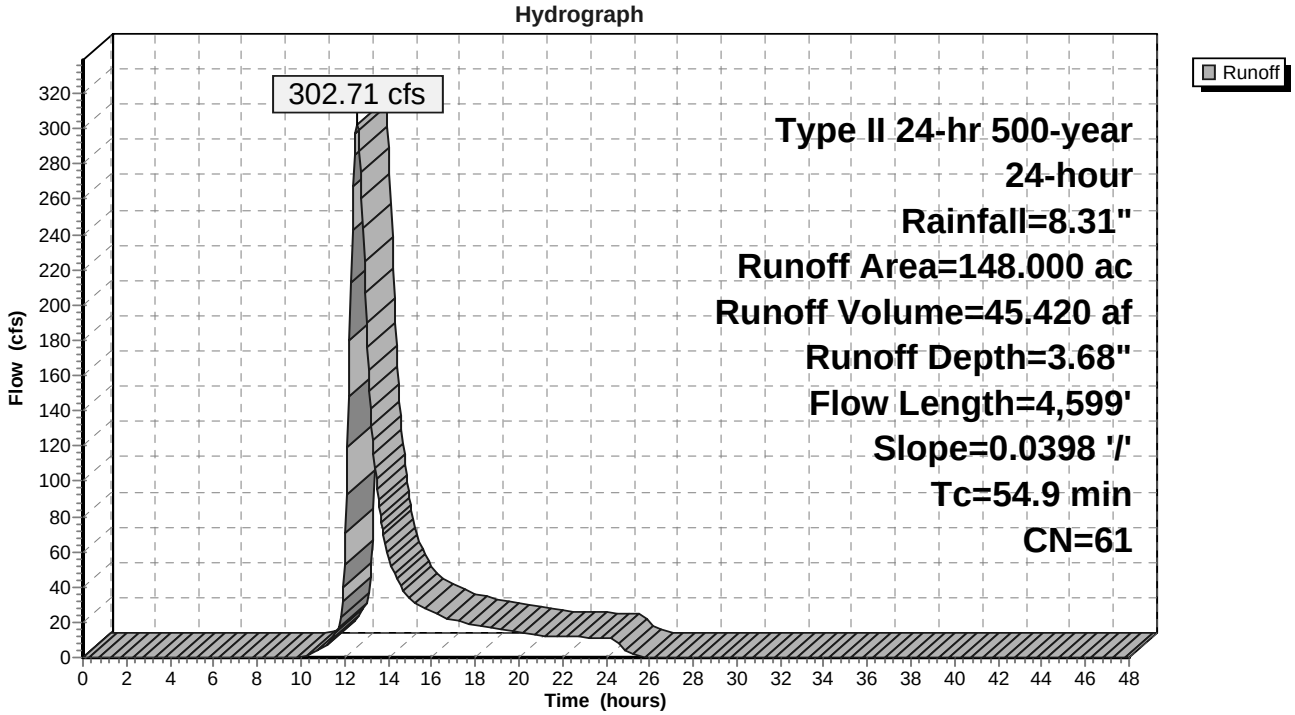
Runoff = 302.71 cfs @ 12.58 hrs, Volume= 45.420 af, Depth= 3.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	148.000	61	Composite CN
	148.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
54.9	4,599	0.0398	1.40		**Shallow Concentrated Flow, Overland Flow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S6: NA_4



Summary for Subcatchment S7: ASHBODY-1

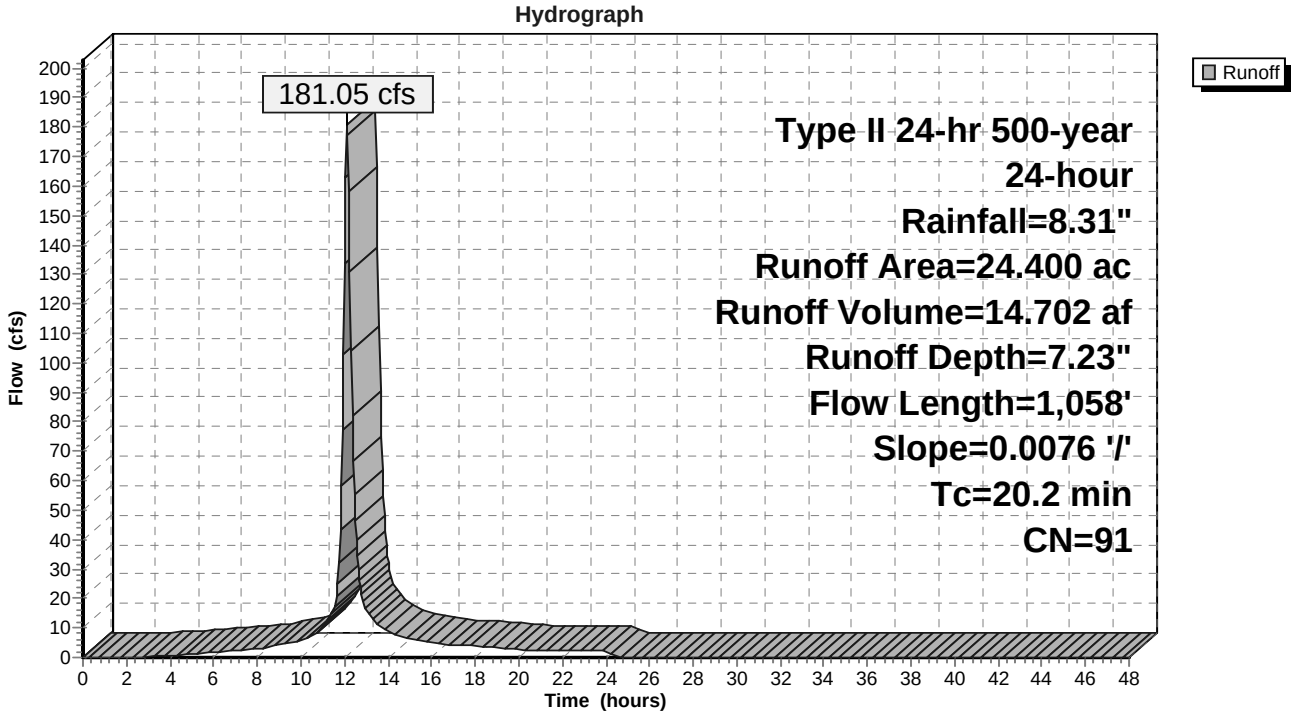
Runoff = 181.05 cfs @ 12.12 hrs, Volume= 14.702 af, Depth= 7.23"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	24.400	91	Newly Graded Areas, HSG C (Silt)
	24.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.2	1,058	0.0076	0.87		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S7: ASHBODY-1



Summary for Subcatchment S8: ASHBODY-2

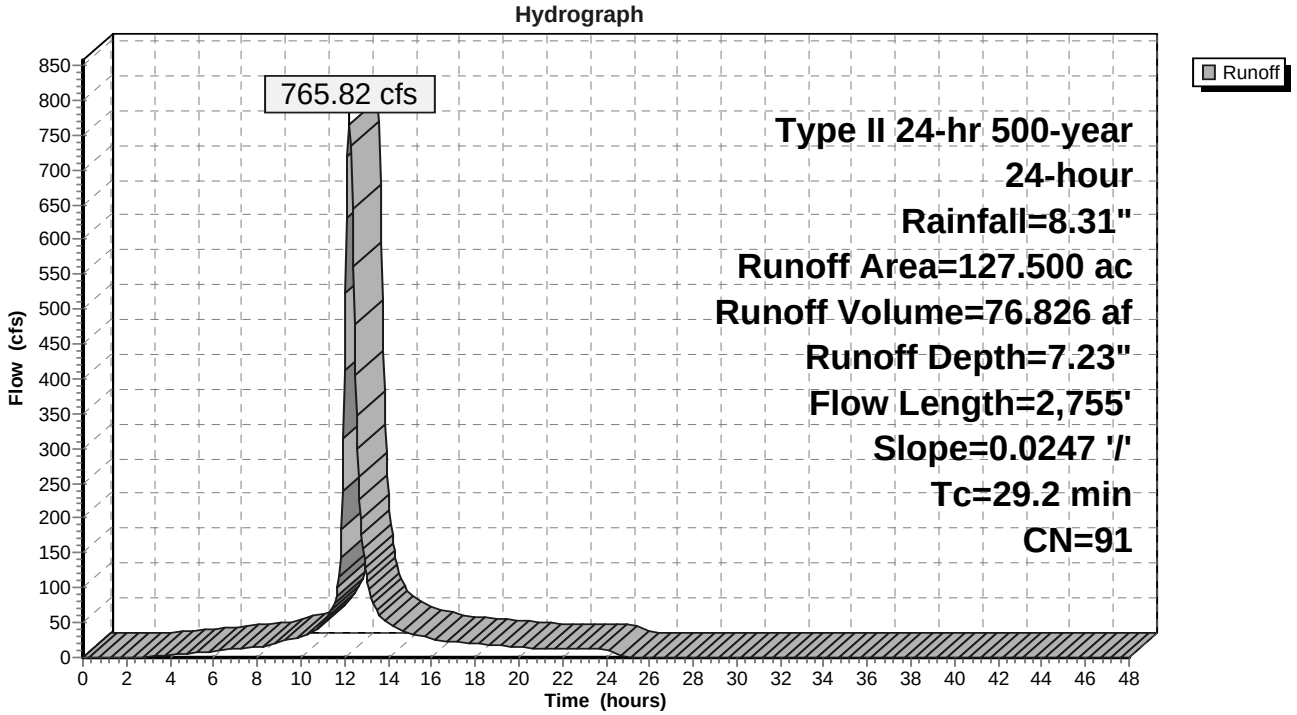
Runoff = 765.82 cfs @ 12.22 hrs, Volume= 76.826 af, Depth= 7.23"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	127.500	91	Newly Graded Areas, HSG C (Silt)
	127.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.2	2,755	0.0247	1.57		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S8: ASHBODY-2



Summary for Subcatchment S9: ASHBODY-3

[49] Hint: Tc<2dt may require smaller dt

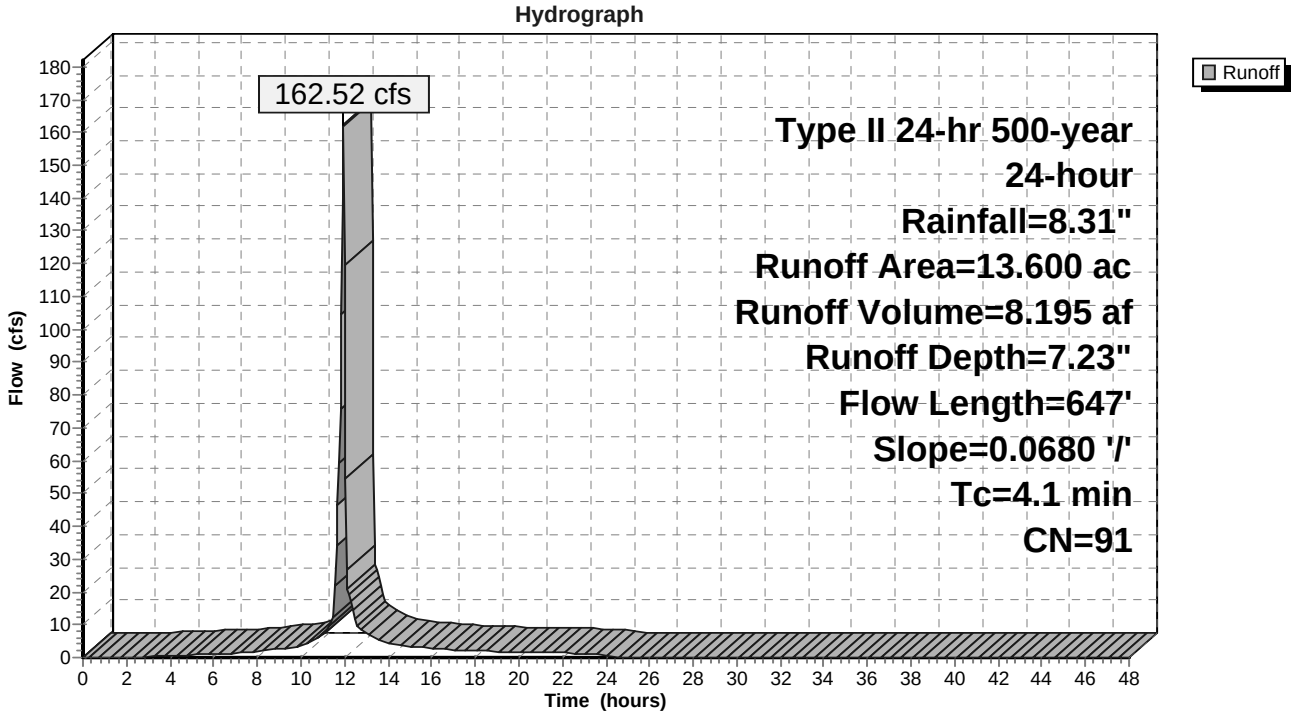
Runoff = 162.52 cfs @ 11.94 hrs, Volume= 8.195 af, Depth= 7.23"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 500-year, 24-hour Rainfall=8.31"

	Area (ac)	CN	Description
*	13.600	91	Newly Graded Areas, HSG C (Silt)
	13.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	647	0.0680	2.61		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S9: ASHBODY-3



Summary for Pond P1: PC

[81] Warning: Exceeded Pond P2 by 0.26' @ 24.90 hrs

Inflow Area = 2,793.197 ac, 2.42% Impervious, Inflow Depth = 4.08" for 500-year, 24-hour event
Inflow = 1,213.38 cfs @ 14.97 hrs, Volume= 950.341 af
Outflow = 1,171.58 cfs @ 16.43 hrs, Volume= 950.341 af, Atten= 3%, Lag= 88.0 min
Primary = 873.01 cfs @ 16.43 hrs, Volume= 810.298 af
Secondary = 298.57 cfs @ 16.43 hrs, Volume= 140.043 af
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 745.75' @ 16.43 hrs Surf.Area= 0.000 ac Storage= 43.375 af

Plug-Flow detention time= 17.6 min calculated for 950.339 af (100% of inflow)
Center-of-Mass det. time= 17.6 min (1,055.2 - 1,037.7)

Volume	Invert	Avail.Storage	Storage Description
#1	741.00'	158.188 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
741.00	0.000
742.00	2.013
744.00	15.695
746.00	47.335
748.00	93.924
750.00	158.188

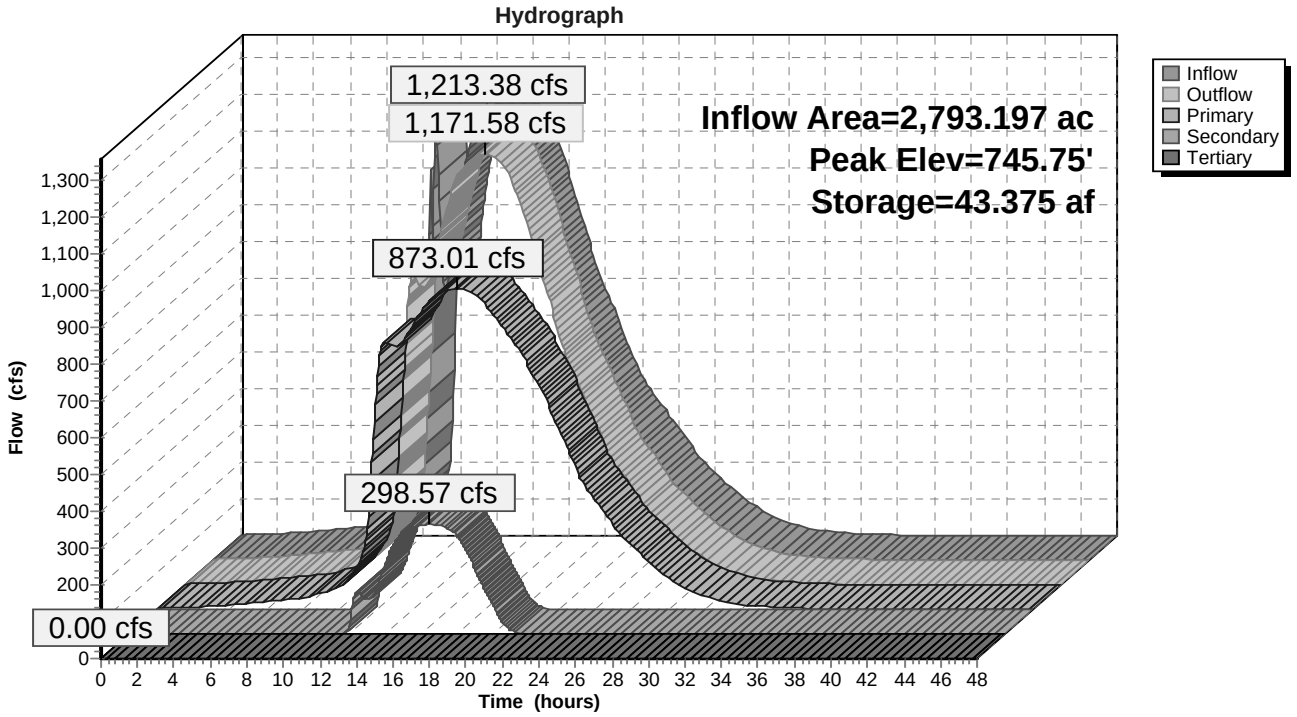
Device	Routing	Invert	Outlet Devices
#1	Secondary	743.00'	**60.0" Horiz. Overflow Pipe 1** C= 0.600 Limited to weir flow at low heads
#2	Secondary	743.50'	**60.0" Horiz. Overflow Pipe 2** C= 0.600 Limited to weir flow at low heads
#3	Primary	736.50'	**58.8" Round O_CU X 5.00** L= 115.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 736.50' / 736.00' S= 0.0043 '/' Cc= 0.900 n= 0.011 PVC, smooth interior
#4	Tertiary	746.00'	**144.0 deg x 4.4' long x 4.00' rise Spillway** C= 2.57

Primary OutFlow Max=873.01 cfs @ 16.43 hrs HW=745.75' TW=741.00' (Fixed TW Elev= 741.00')
└─**3=O_CU** (Inlet Controls 873.01 cfs @ 9.26 fps)

Secondary OutFlow Max=298.57 cfs @ 16.43 hrs HW=745.75' TW=741.00' (Fixed TW Elev= 741.00')
├─**1=Overflow Pipe 1** (Orifice Controls 156.77 cfs @ 7.98 fps)
└─**2=Overflow Pipe 2** (Orifice Controls 141.80 cfs @ 7.22 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=741.00' TW=741.00' (Fixed TW Elev= 741.00')
└─**4=Spillway** (Controls 0.00 cfs)

Pond P1: PC


Hydrograph
1,213.38 cfs
1,171.58 cfs
873.01 cfs
298.57 cfs
0.00 cfs
Inflow Area=2,793.197 ac
Peak Elev=745.75'
Storage=43.375 af
Inflow
Outflow
Primary
Secondary
Tertiary
Flow (cfs)
0
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Time (hours)

Summary for Pond P2: PN

Inflow Area = 1,109.118 ac, 2.77% Impervious, Inflow Depth = 3.82" for 500-year, 24-hour event
Inflow = 786.26 cfs @ 11.92 hrs, Volume= 352.781 af
Outflow = 427.48 cfs @ 16.38 hrs, Volume= 352.781 af, Atten= 46%, Lag= 267.2 min
Primary = 427.48 cfs @ 16.38 hrs, Volume= 352.781 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 747.18' @ 16.38 hrs Surf.Area= 0.000 ac Storage= 53.802 af

Plug-Flow detention time= 63.3 min calculated for 352.413 af (100% of inflow)
Center-of-Mass det. time= 63.2 min (1,043.8 - 980.6)

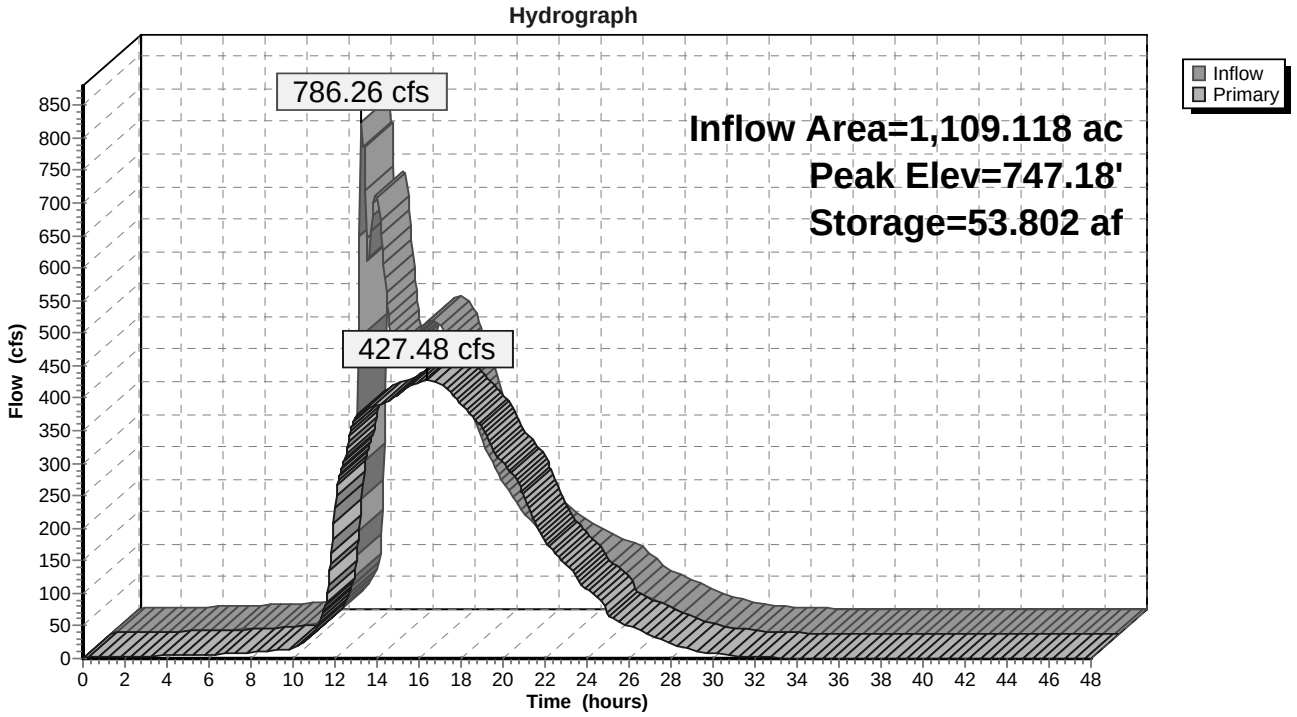
Volume	Invert	Avail.Storage	Storage Description
#1	741.00'	101.017 af	**Pond North** Listed below

Elevation (feet)	Cum.Store (acre-feet)
741.00	0.000
742.00	1.977
744.00	14.791
746.00	36.569
748.00	65.872
750.00	101.017

Device	Routing	Invert	Outlet Devices
#1	Primary	747.10'	**48.0" Round Culvert_1** L= 68.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 747.10' / 745.00' S= 0.0309 '/' Cc= 0.900 n= 0.030 Corrugated metal
#2	Primary	745.00'	**48.0" Round Culvert_2** L= 66.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 745.00' / 745.00' S= 0.0000 '/' Cc= 0.900 n= 0.030 Corrugated metal
#3	Primary	745.30'	**48.0" Round Culvert_3** L= 66.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 745.30' / 745.00' S= 0.0045 '/' Cc= 0.900 n= 0.030 Corrugated metal
#4	Primary	738.50'	**58.8" Round NED_CU X 2.00** L= 137.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 738.50' / 738.00' S= 0.0036 '/' Cc= 0.900 n= 0.011 PVC, smooth interior

Primary OutFlow Max=427.46 cfs @ 16.38 hrs HW=747.18' (Free Discharge)
- **1=Culvert_1** (Barrel Controls 0.04 cfs @ 0.98 fps)
- **2=Culvert_2** (Barrel Controls 14.27 cfs @ 2.96 fps)
- **3=Culvert_3** (Barrel Controls 13.34 cfs @ 3.38 fps)
- **4=NED_CU** (Inlet Controls 399.81 cfs @ 10.60 fps)

Pond P2: PN


Hydrograph
786.26 cfs
427.48 cfs
Inflow Area=1,109.118 ac
Peak Elev=747.18'
Storage=53.802 af
Inflow
Primary
Flow (cfs)
Time (hours)
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48

Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment S1: SA_1 Runoff Area=882.000 ac 0.00% Impervious Runoff Depth=4.84"
Flow Length=12,641' Slope=0.0146 '/' Tc=348.7 min CN=66 Runoff=589.60 cfs 355.793 af

Subcatchment S10: PN Area Runoff Area=30.718 ac 100.00% Impervious Runoff Depth=9.00"
Tc=0.0 min CN=100 Runoff=444.38 cfs 23.039 af

Subcatchment S11: PC Area Runoff Area=36.979 ac 100.00% Impervious Runoff Depth=9.00"
Tc=0.0 min CN=100 Runoff=534.96 cfs 27.734 af

Subcatchment S2: SA_2 Runoff Area=624.000 ac 0.00% Impervious Runoff Depth=3.86"
Flow Length=8,746' Slope=0.0308 '/' Tc=166.1 min CN=58 Runoff=573.81 cfs 200.464 af

Subcatchment S3: NA_1 Runoff Area=176.000 ac 0.00% Impervious Runoff Depth=3.86"
Flow Length=3,358' Slope=0.0259 '/' Tc=69.6 min CN=58 Runoff=314.43 cfs 56.541 af

Subcatchment S4: NA_2 Runoff Area=646.000 ac 0.00% Impervious Runoff Depth=4.22"
Flow Length=6,729' Slope=0.0036 '/' Tc=267.0 min CN=61 Runoff=450.16 cfs 227.384 af

Subcatchment S5: NA_3 Runoff Area=84.000 ac 0.00% Impervious Runoff Depth=3.98"
Flow Length=1,252' Slope=0.0935 '/' Tc=9.7 min CN=59 Runoff=511.52 cfs 27.845 af

Subcatchment S6: NA_4 Runoff Area=148.000 ac 0.00% Impervious Runoff Depth=4.22"
Flow Length=4,599' Slope=0.0398 '/' Tc=54.9 min CN=61 Runoff=349.67 cfs 52.094 af

Subcatchment S7: ASHBODY-1 Runoff Area=24.400 ac 0.00% Impervious Runoff Depth=7.91"
Flow Length=1,058' Slope=0.0076 '/' Tc=20.2 min CN=91 Runoff=197.19 cfs 16.090 af

Subcatchment S8: ASHBODY-2 Runoff Area=127.500 ac 0.00% Impervious Runoff Depth=7.91"
Flow Length=2,755' Slope=0.0247 '/' Tc=29.2 min CN=91 Runoff=834.31 cfs 84.077 af

Subcatchment S9: ASHBODY-3 Runoff Area=13.600 ac 0.00% Impervious Runoff Depth=7.91"
Flow Length=647' Slope=0.0680 '/' Tc=4.1 min CN=91 Runoff=176.84 cfs 8.968 af

Pond P1: PC Peak Elev=746.64' Storage=62.288 af Inflow=1,388.85 cfs 1,080.028 af
ary=951.48 cfs 891.923 af Secondary=347.99 cfs 186.429 af Tertiary=9.91 cfs 1.677 af Outflow=1,309.38 cfs 1,080.028 af

Pond P2: PN Peak Elev=748.09' Storage=67.467 af Inflow=890.66 cfs 402.993 af
Outflow=491.57 cfs 402.993 af

Total Runoff Area = 2,793.197 ac Runoff Volume = 1,080.028 af Average Runoff Depth = 4.64"
97.58% Pervious = 2,725.500 ac 2.42% Impervious = 67.697 ac

Summary for Subcatchment S1: SA_1

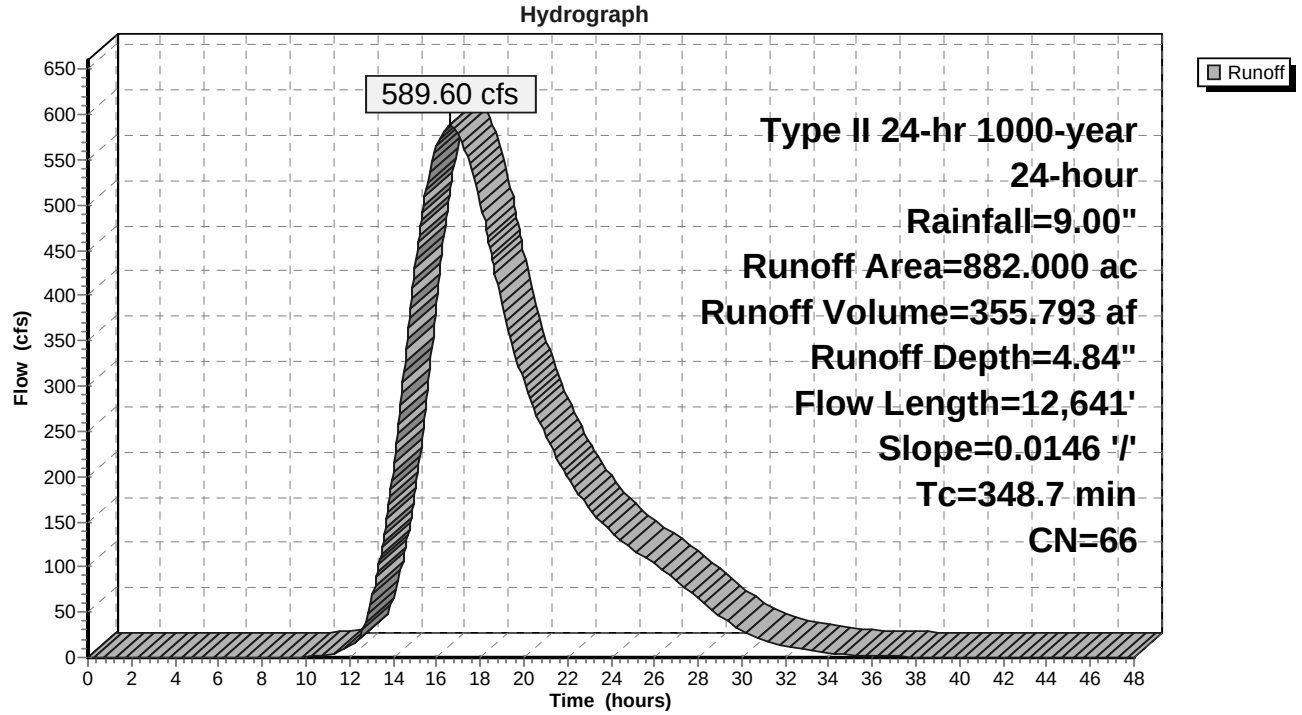
Runoff = 589.60 cfs @ 16.65 hrs, Volume= 355.793 af, Depth= 4.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	882.000	66	Composite CN
	882.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
348.7	12,641	0.0146	0.60		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S1: SA_1



Summary for Subcatchment S10: PN Area

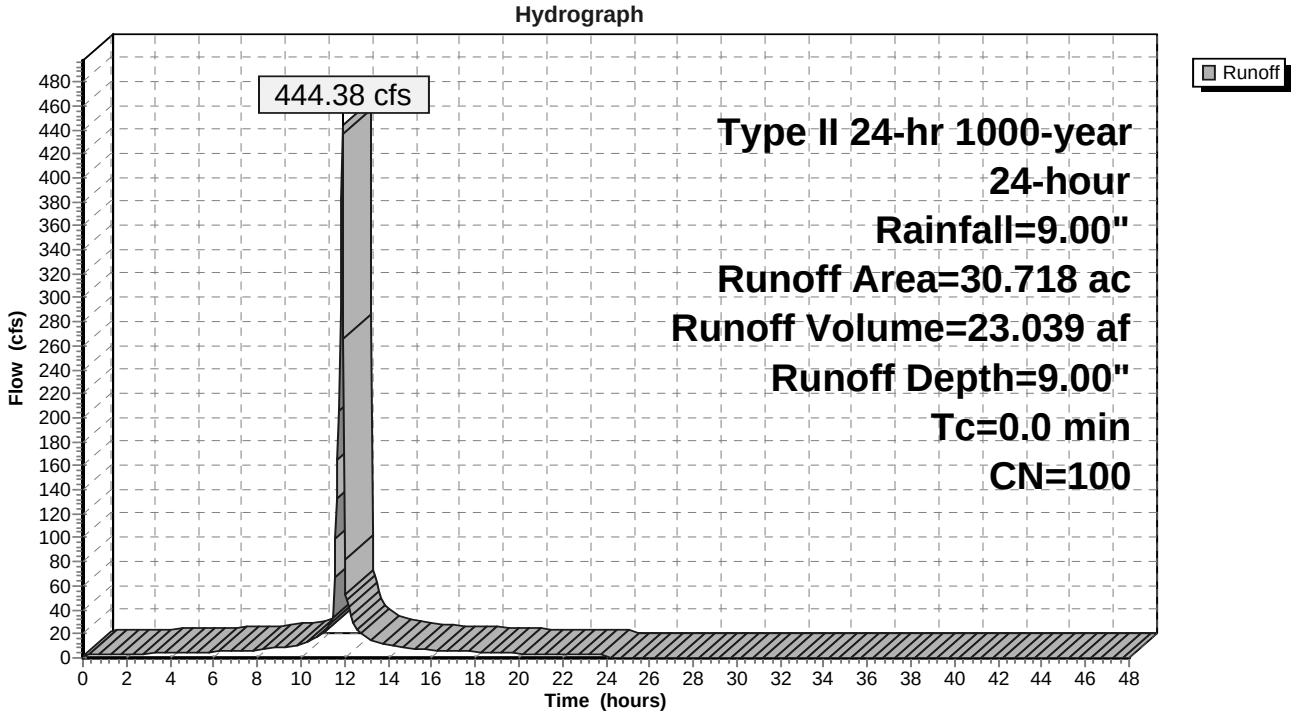
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 444.38 cfs @ 11.89 hrs, Volume= 23.039 af, Depth= 9.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	30.718	100	Pond
	30.718		100.00% Impervious Area

Subcatchment S10: PN Area



Summary for Subcatchment S11: PC Area

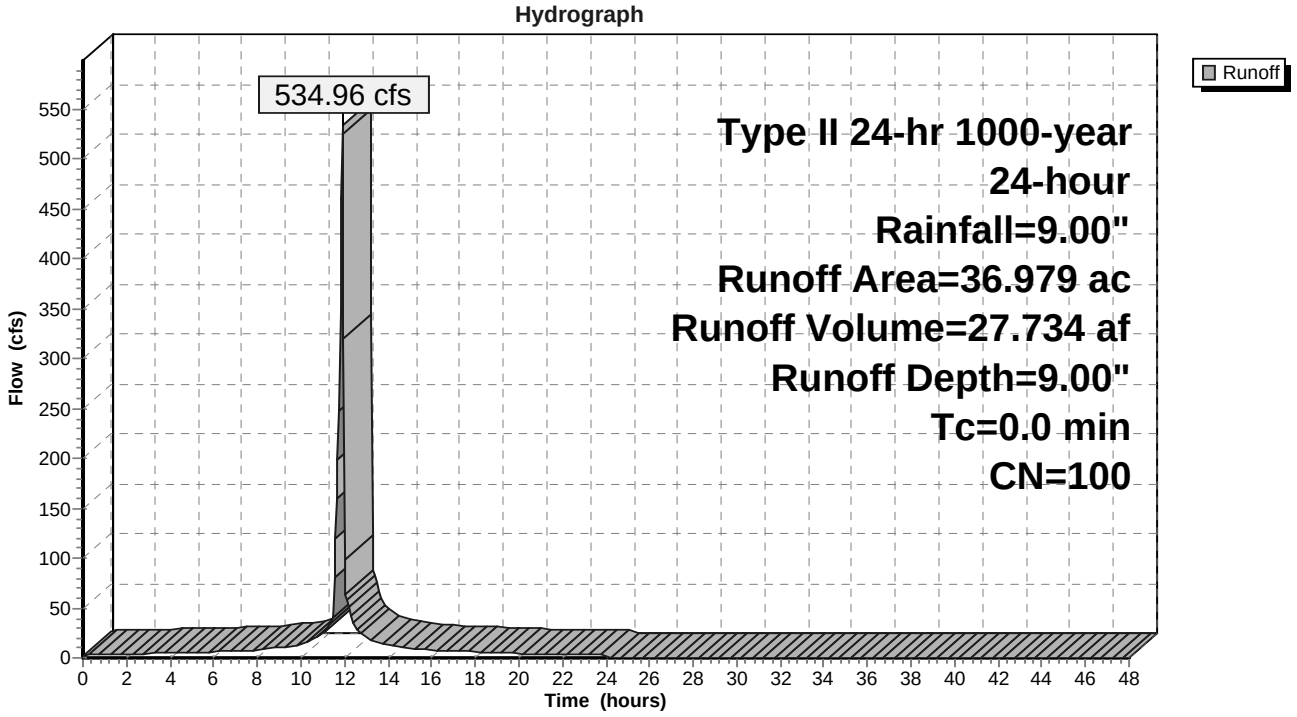
[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 534.96 cfs @ 11.89 hrs, Volume= 27.734 af, Depth= 9.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	36.979	100	Pond
	36.979		100.00% Impervious Area

Subcatchment S11: PC Area



Summary for Subcatchment S2: SA_2

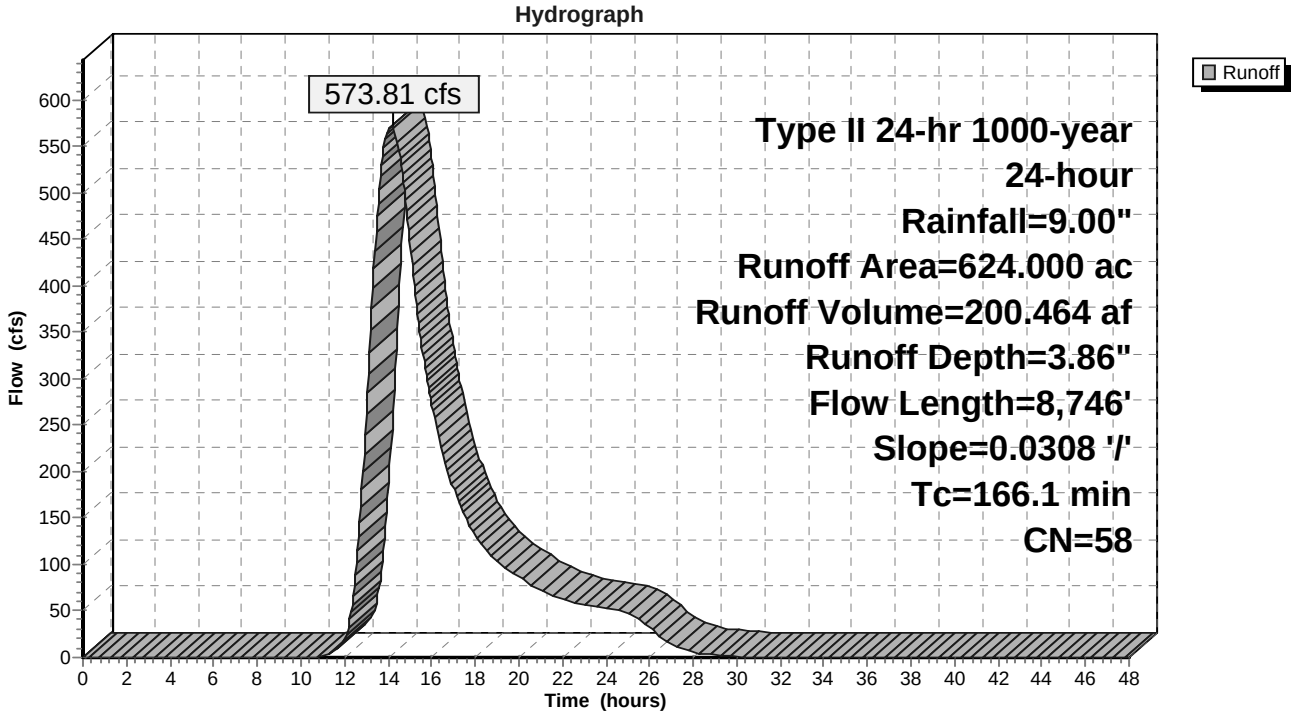
Runoff = 573.81 cfs @ 14.19 hrs, Volume= 200.464 af, Depth= 3.86"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	624.000	58	Composite CN
	624.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
166.1	8,746	0.0308	0.88		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S2: SA_2



Summary for Subcatchment S3: NA_1

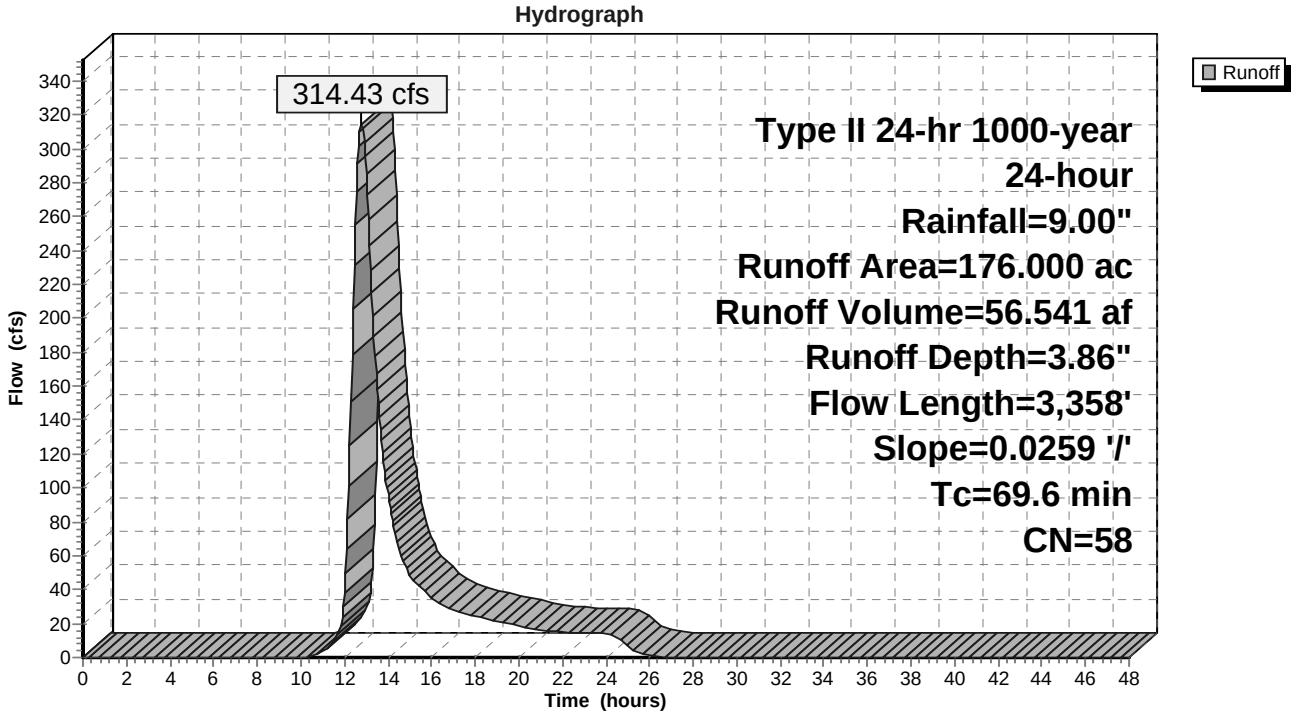
Runoff = 314.43 cfs @ 12.77 hrs, Volume= 56.541 af, Depth= 3.86"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	176.000	58	Composite CN
	176.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
69.6	3,358	0.0259	0.80		**Shallow Concentrated Flow, Overland Flow** Woodland Kv= 5.0 fps

Subcatchment S3: NA_1



Summary for Subcatchment S4: NA_2

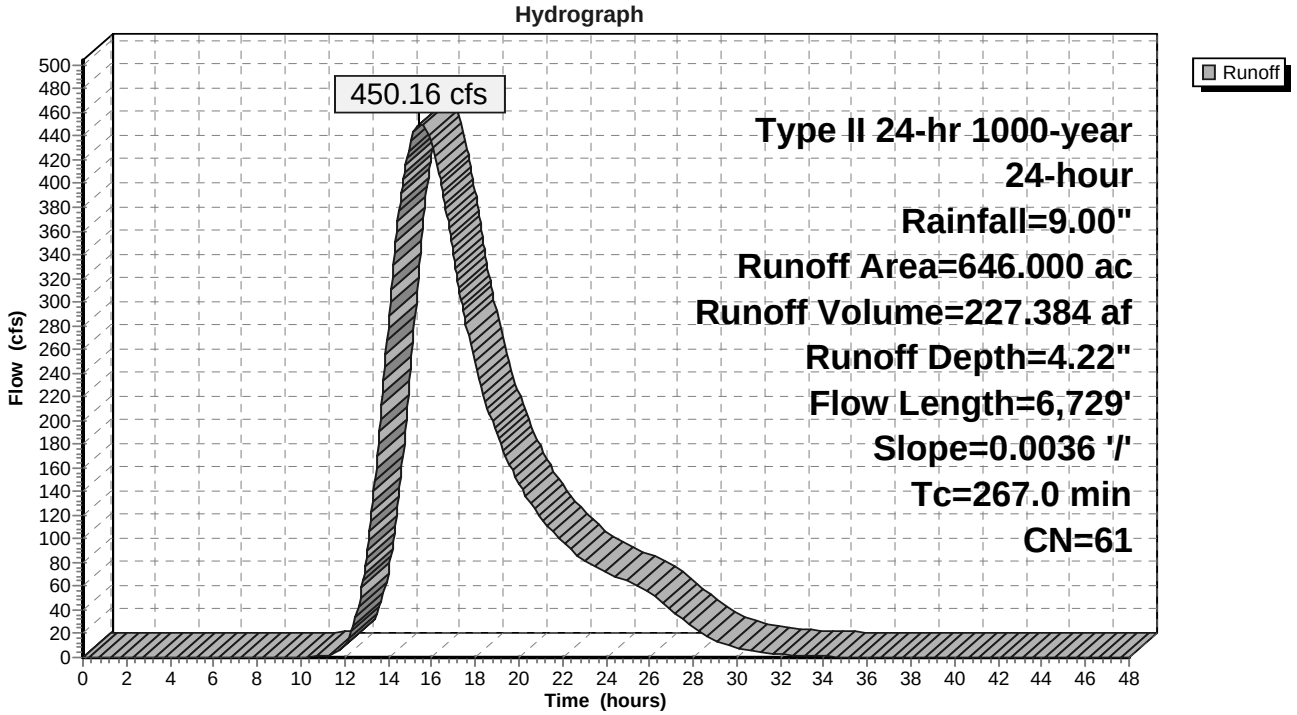
Runoff = 450.16 cfs @ 15.46 hrs, Volume= 227.384 af, Depth= 4.22"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	646.000	61	Composite CN
	646.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
267.0	6,729	0.0036	0.42		**Shallow Concentrated Flow, Overland FLow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S4: NA_2



Summary for Subcatchment S5: NA_3

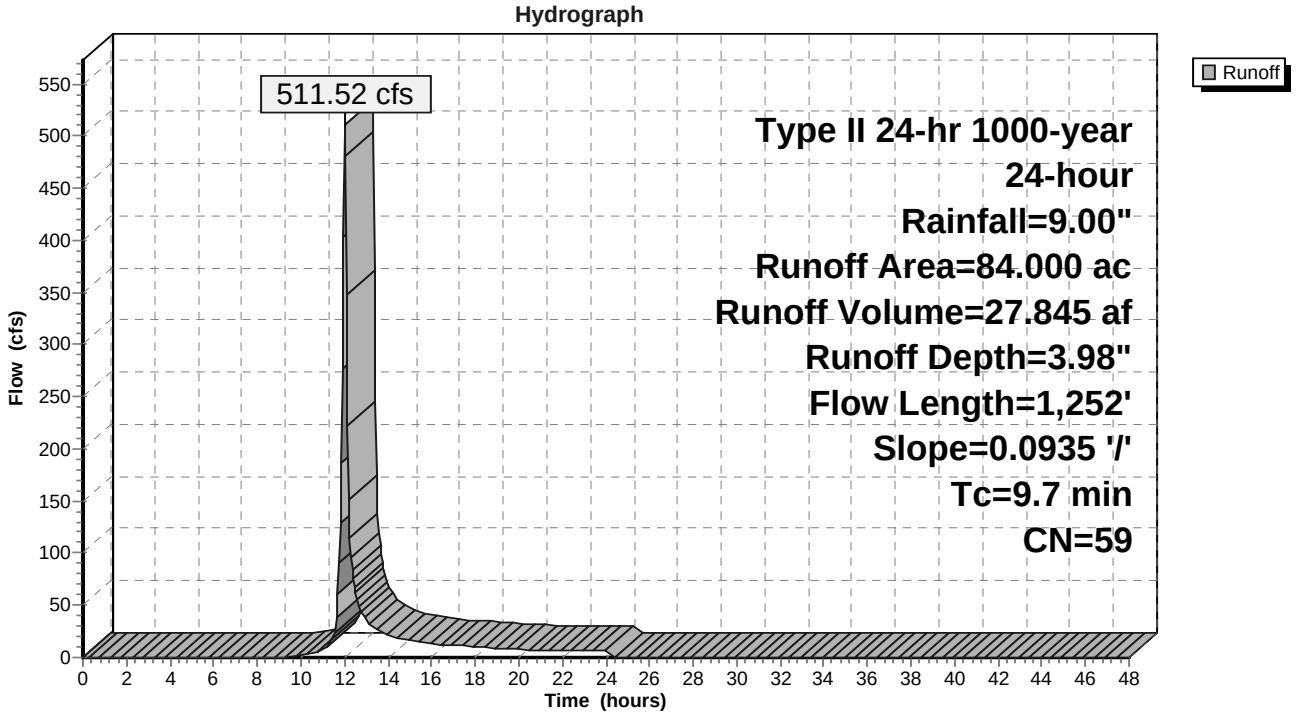
Runoff = 511.52 cfs @ 12.02 hrs, Volume= 27.845 af, Depth= 3.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	84.000	59	Composite CN
	84.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.7	1,252	0.0935	2.14		**Shallow Concentrated Flow, Overland Flow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S5: NA_3



Summary for Subcatchment S6: NA_4

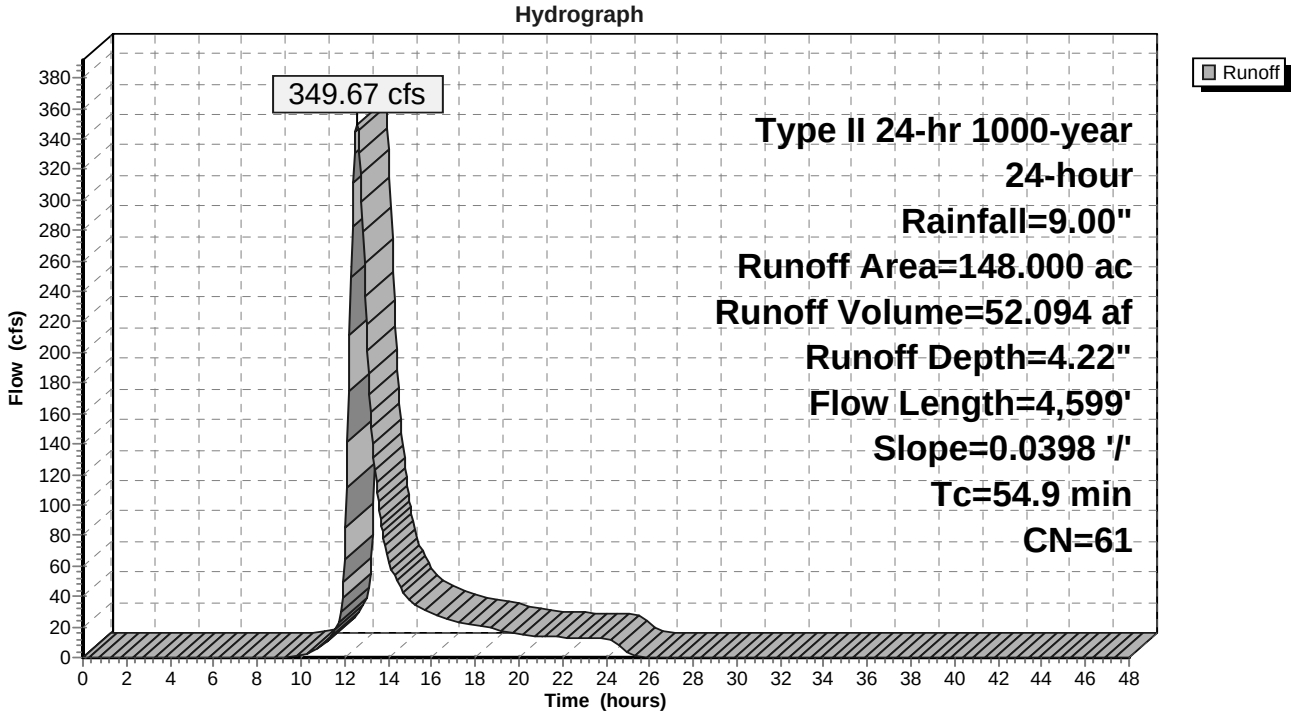
Runoff = 349.67 cfs @ 12.57 hrs, Volume= 52.094 af, Depth= 4.22"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	148.000	61	Composite CN
	148.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
54.9	4,599	0.0398	1.40		**Shallow Concentrated Flow, Overland Flow** Short Grass Pasture Kv= 7.0 fps

Subcatchment S6: NA_4



Summary for Subcatchment S7: ASHBODY-1

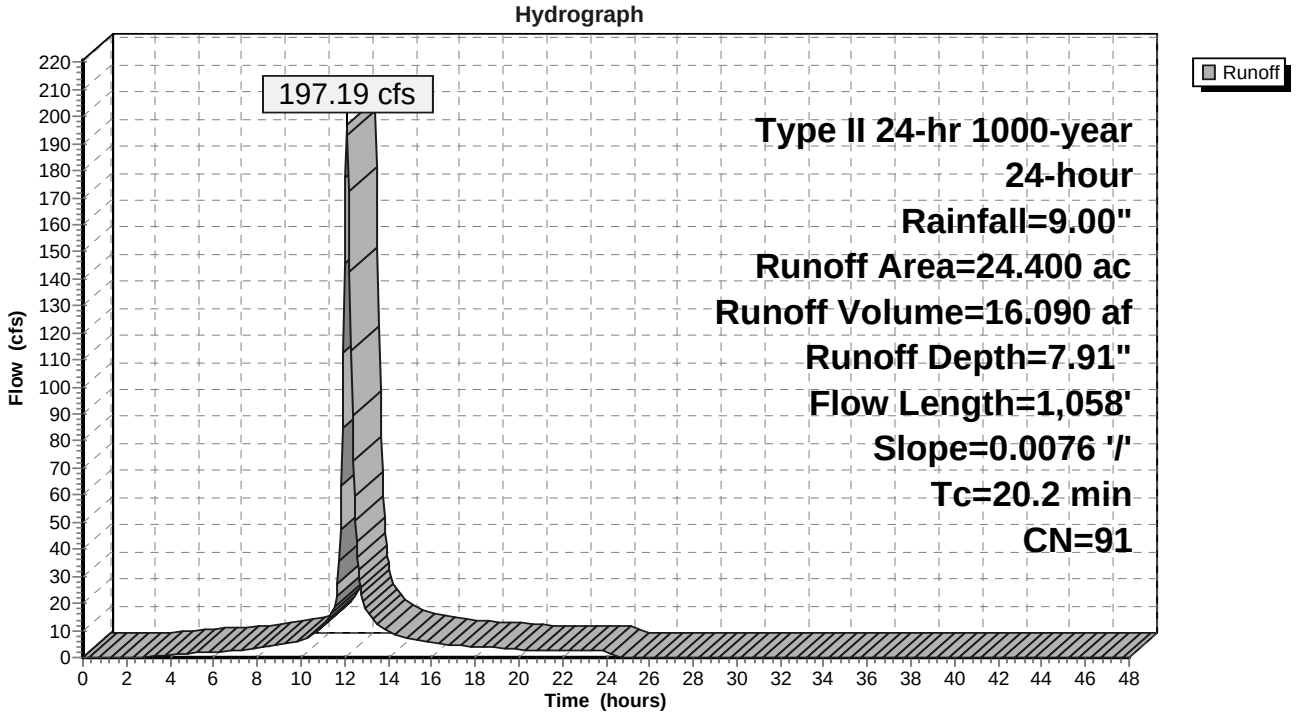
Runoff = 197.19 cfs @ 12.12 hrs, Volume= 16.090 af, Depth= 7.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	24.400	91	Newly Graded Areas, HSG C (Silt)
	24.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.2	1,058	0.0076	0.87		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S7: ASHBODY-1



Summary for Subcatchment S8: ASHBODY-2

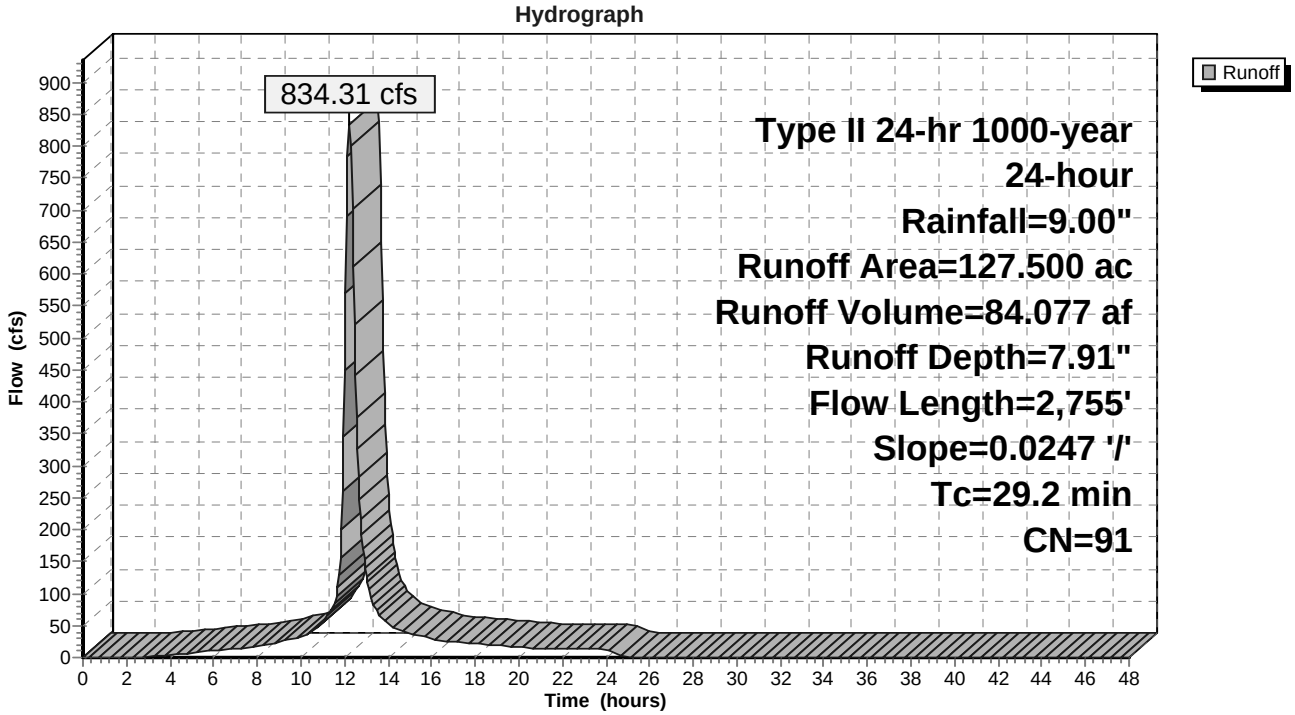
Runoff = 834.31 cfs @ 12.22 hrs, Volume= 84.077 af, Depth= 7.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	127.500	91	Newly Graded Areas, HSG C (Silt)
	127.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
29.2	2,755	0.0247	1.57		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S8: ASHBODY-2



Summary for Subcatchment S9: ASHBODY-3

[49] Hint: Tc<2dt may require smaller dt

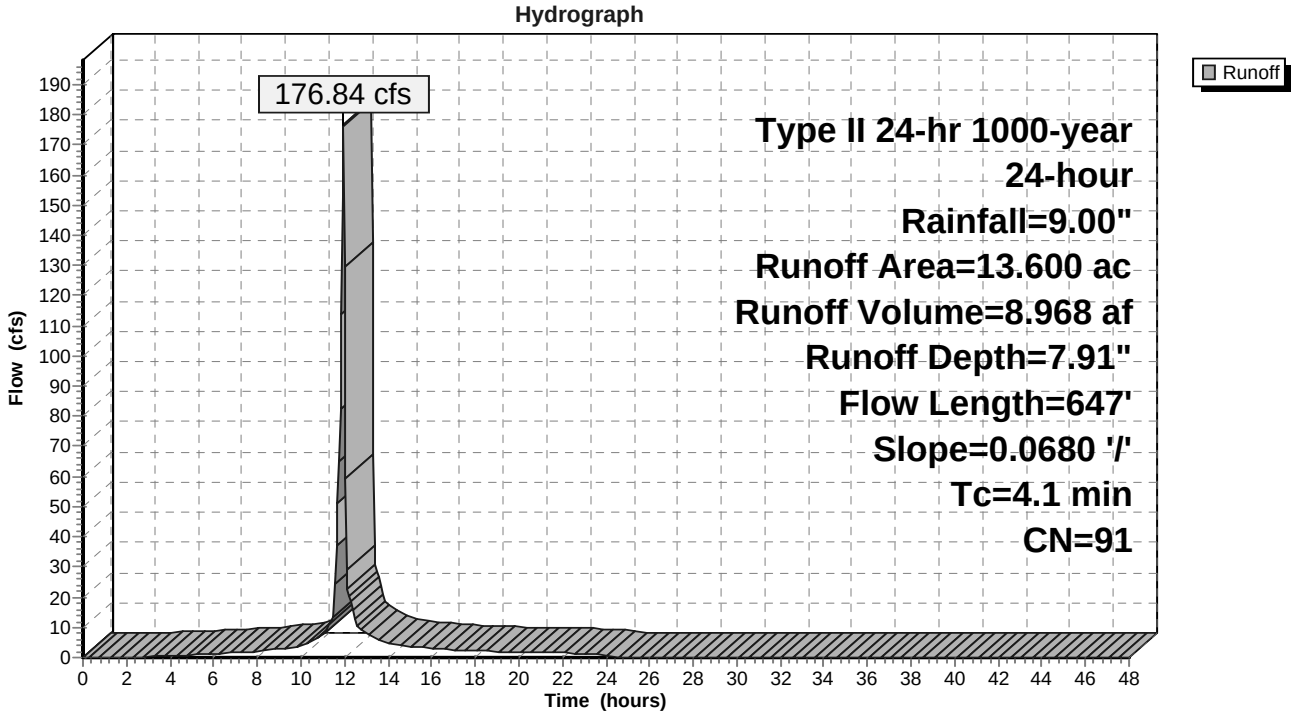
Runoff = 176.84 cfs @ 11.94 hrs, Volume= 8.968 af, Depth= 7.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 1000-year, 24-hour Rainfall=9.00"

	Area (ac)	CN	Description
*	13.600	91	Newly Graded Areas, HSG C (Silt)
	13.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.1	647	0.0680	2.61		**Shallow Concentrated Flow, Overland Flow** Nearly Bare & Untilled Kv= 10.0 fps

Subcatchment S9: ASHBODY-3



Summary for Pond P1: PC

[81] Warning: Exceeded Pond P2 by 0.29' @ 25.25 hrs

Inflow Area = 2,793.197 ac, 2.42% Impervious, Inflow Depth = 4.64" for 1000-year, 24-hour event
Inflow = 1,388.85 cfs @ 14.97 hrs, Volume= 1,080.028 af
Outflow = 1,309.38 cfs @ 16.75 hrs, Volume= 1,080.028 af, Atten= 6%, Lag= 107.0 min
Primary = 951.48 cfs @ 16.75 hrs, Volume= 891.923 af
Secondary = 347.99 cfs @ 16.75 hrs, Volume= 186.429 af
Tertiary = 9.91 cfs @ 16.75 hrs, Volume= 1.677 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 746.64' @ 16.75 hrs Surf.Area= 0.000 ac Storage= 62.288 af

Plug-Flow detention time= 21.7 min calculated for 1,078.902 af (100% of inflow)
Center-of-Mass det. time= 21.7 min (1,060.5 - 1,038.9)

Volume	Invert	Avail.Storage	Storage Description
#1	741.00'	158.188 af	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (acre-feet)
741.00	0.000
742.00	2.013
744.00	15.695
746.00	47.335
748.00	93.924
750.00	158.188

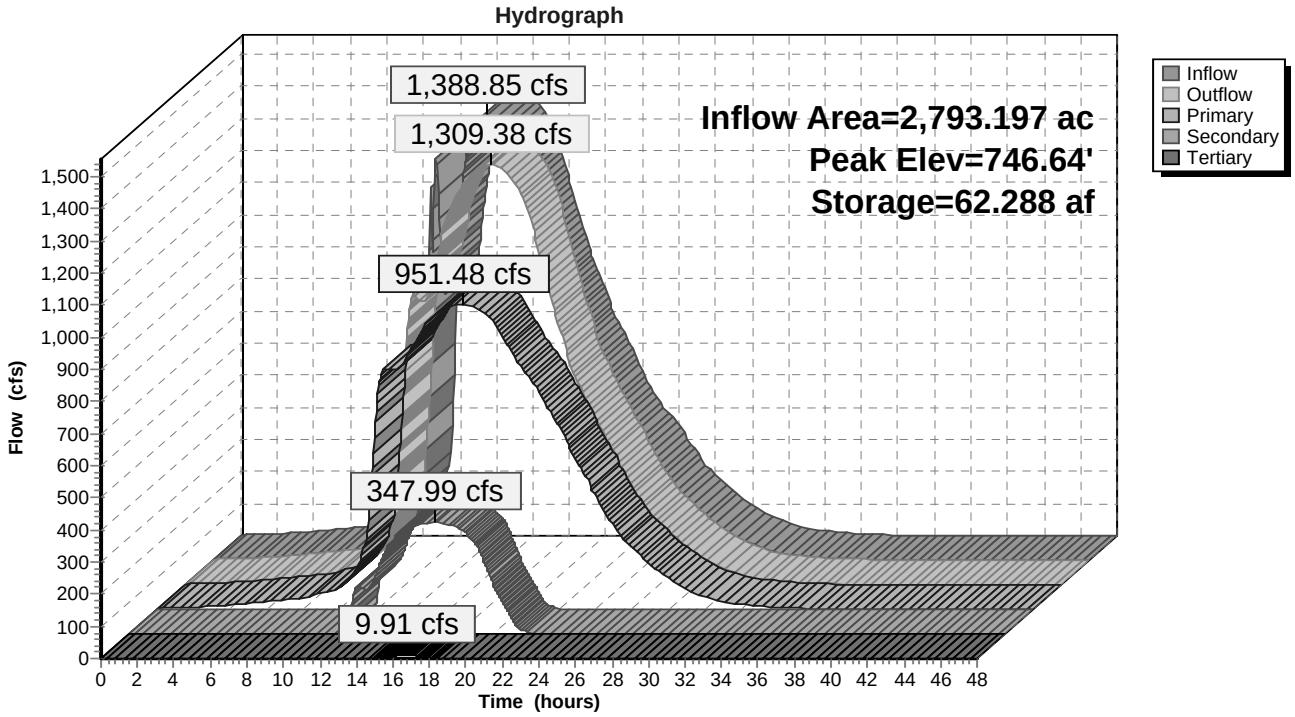
Device	Routing	Invert	Outlet Devices
#1	Secondary	743.00'	**60.0" Horiz. Overflow Pipe 1** C= 0.600 Limited to weir flow at low heads
#2	Secondary	743.50'	**60.0" Horiz. Overflow Pipe 2** C= 0.600 Limited to weir flow at low heads
#3	Primary	736.50'	**58.8" Round O_CU X 5.00** L= 115.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 736.50' / 736.00' S= 0.0043 '/' Cc= 0.900 n= 0.011 PVC, smooth interior
#4	Tertiary	746.00'	**144.0 deg x 4.4' long x 4.00' rise Spillway** C= 2.57

Primary OutFlow Max=951.48 cfs @ 16.75 hrs HW=746.64' TW=741.00' (Fixed TW Elev= 741.00')
└─**3=O_CU** (Inlet Controls 951.48 cfs @ 10.09 fps)

Secondary OutFlow Max=348.00 cfs @ 16.75 hrs HW=746.64' TW=741.00' (Fixed TW Elev= 741.00')
├─**1=Overflow Pipe 1** (Orifice Controls 180.42 cfs @ 9.19 fps)
└─**2=Overflow Pipe 2** (Orifice Controls 167.58 cfs @ 8.53 fps)

Tertiary OutFlow Max=9.88 cfs @ 16.75 hrs HW=746.64' TW=741.00' (Fixed TW Elev= 741.00')
└─**4=Spillway** (Weir Controls 9.88 cfs @ 2.41 fps)

Pond P1: PC


Hydrograph
1,388.85 cfs
1,309.38 cfs
951.48 cfs
347.99 cfs
9.91 cfs
Inflow Area=2,793.197 ac
Peak Elev=746.64'
Storage=62.288 af
Inflow
Outflow
Primary
Secondary
Tertiary
Flow (cfs)
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Time (hours)

Summary for Pond P2: PN

Inflow Area = 1,109.118 ac, 2.77% Impervious, Inflow Depth = 4.36" for 1000-year, 24-hour event
Inflow = 890.66 cfs @ 11.92 hrs, Volume= 402.993 af
Outflow = 491.57 cfs @ 16.35 hrs, Volume= 402.993 af, Atten= 45%, Lag= 265.5 min
Primary = 491.57 cfs @ 16.35 hrs, Volume= 402.993 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 748.09' @ 16.35 hrs Surf.Area= 0.000 ac Storage= 67.467 af

Plug-Flow detention time= 72.0 min calculated for 402.991 af (100% of inflow)
Center-of-Mass det. time= 71.9 min (1,049.9 - 978.0)

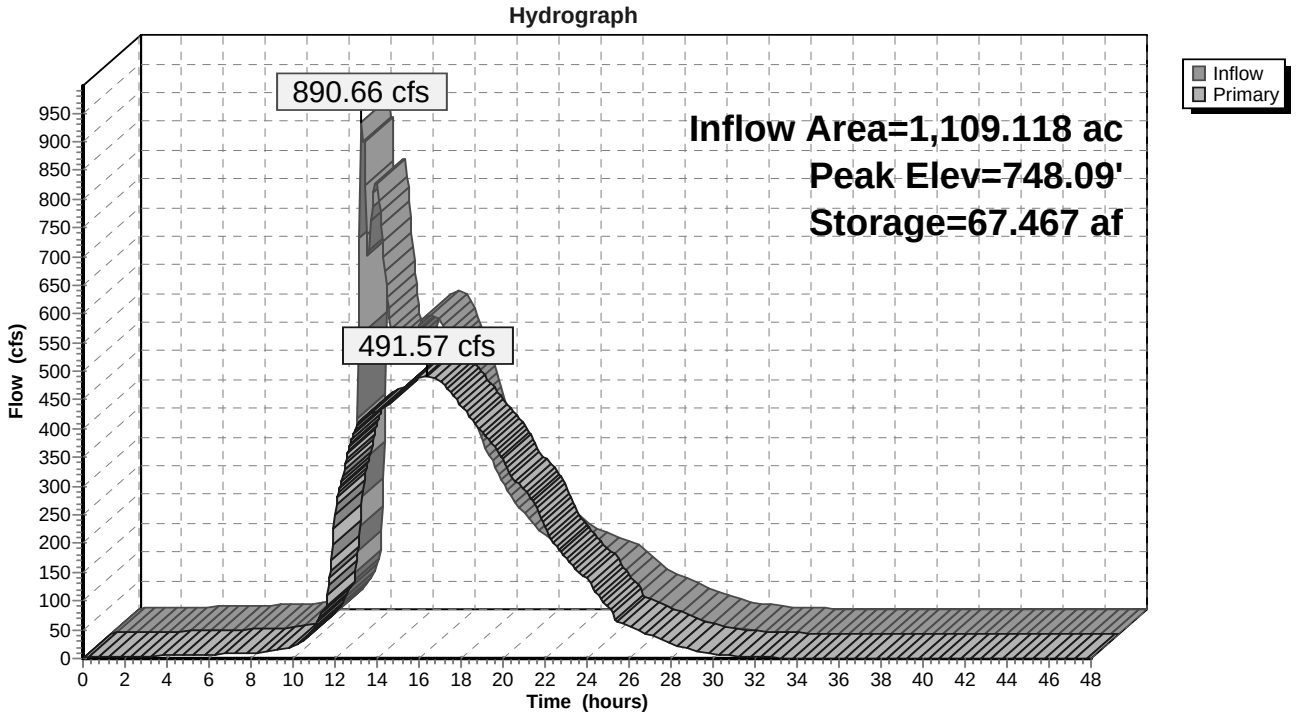
Volume	Invert	Avail.Storage	Storage Description
#1	741.00'	101.017 af	**Pond North** Listed below

Elevation (feet)	Cum.Store (acre-feet)
741.00	0.000
742.00	1.977
744.00	14.791
746.00	36.569
748.00	65.872
750.00	101.017

Device	Routing	Invert	Outlet Devices
#1	Primary	747.10'	**48.0" Round Culvert_1** L= 68.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 747.10' / 745.00' S= 0.0309 '/' Cc= 0.900 n= 0.030 Corrugated metal
#2	Primary	745.00'	**48.0" Round Culvert_2** L= 66.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 745.00' / 745.00' S= 0.0000 '/' Cc= 0.900 n= 0.030 Corrugated metal
#3	Primary	745.30'	**48.0" Round Culvert_3** L= 66.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 745.30' / 745.00' S= 0.0045 '/' Cc= 0.900 n= 0.030 Corrugated metal
#4	Primary	738.50'	**58.8" Round NED_CU X 2.00** L= 137.0' CPP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 738.50' / 738.00' S= 0.0036 '/' Cc= 0.900 n= 0.011 PVC, smooth interior

Primary OutFlow Max=491.56 cfs @ 16.35 hrs HW=748.09' (Free Discharge)
- **1=Culvert_1** (Inlet Controls 6.49 cfs @ 2.68 fps)
- **2=Culvert_2** (Barrel Controls 28.68 cfs @ 3.80 fps)
- **3=Culvert_3** (Barrel Controls 28.22 cfs @ 4.24 fps)
- **4=NED_CU** (Inlet Controls 428.18 cfs @ 11.35 fps)

Pond P2: PN


Hydrograph
890.66 cfs
491.57 cfs
Inflow Area=1,109.118 ac
Peak Elev=748.09'
Storage=67.467 af
Inflow
Primary
Flow (cfs)
Time (hours)

APPENDIX – B

GEOTECHNICAL INTEGRITY EVALUATION

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: TVA **Project:** Integrity Evaluation of Dike 2 **Project/Proposal #:** GK4693 **Task #:** 03

TITLE OF COMPUTATIONS **GEOTECHNICAL INTEGRITY EVALUATION**

COMPUTATIONS BY:
Signature [signature] July 12 2010 DATE
Printed Name and Title: Joseph Sura, Senior Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:
(Peer Reviewer)
Signature [signature] 7/12/2010 DATE
Printed Name and Title: Ming Zhu, P.E., Project Engineer

COMPUTATIONS CHECKED BY:
Signature [signature] Fan Zhu 7/12/2010 DATE
Printed Name and Title: Ming Zhu, P.E. / Fan Zhu, Project Engineer / Senior Staff Engineer

COMPUTATIONS BACKCHECKED BY:
(Originator)
Signature [signature] July 12 2010 DATE
Printed Name and Title: Joseph Sura, Senior Staff Engineer

APPROVED BY:
(PM or Designate)
Signature [signature] 12 July 2010 DATE
Printed Name and Title: Ganesh Krishnan, P.E., CPESC, Associate

APPROVAL NOTES: _____

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

Written by:	Joseph Sura	Date:	7/8/2010	Reviewed by:	Ming Zhu	Date:	7/9/2010

Client:	TVA	Project:	Integrity Evaluation of Dike 2	Project/ Proposal No.:	GK4693	Task No.:	03

GEOTECHNICAL INTEGRITY EVALUATION

PURPOSE OF ANALYSES

The purpose of this calculation package is to calculate the slope stability for the existing Dike 2 at the Tennessee Valley Authority (TVA) Kingston site. Slope stability analyses have previously been performed by Geosyntec on Dike 2 in the package titled "Slope Stability Analyses for Dike 2" [Geosyntec, 2009] (hereafter referred to as the 2009 Stability Analyses). The analyses presented herein are intended to calculate the factor of safety (FS) for slope stability under the influence of different water elevations within the Dike 2 basin. Analyses are performed for potential slip surfaces through the embankment and/or subsurface foundation materials.

This package presents the stability analyses for four different water level elevation scenarios within the Dike 2 basin. These include the following.

- Water Elevation 744.5 Feet MSL – Water level elevation lower than the crest of the emergency spillway.
- Water Elevation 746.0 Feet MSL – Water level elevation at the crest of the emergency spillway.
- Water Elevation 748.0 Feet MSL – Water level elevation at approximately half available flow depth in the emergency spillway.
- Water Elevation 750.0 Feet MSL – Water level elevation at the top of the embankment of Dike 2.

METHODOLOGY

Static Stability

Slope stability analyses of circular slip surfaces were performed using Spencer's method [Spencer, 1973], as implemented in the computer program SLIDE, version 5.044 [Rocscience, 2010]. The program was used to generate potential slip surfaces, calculate the factor of safety (FS) for each of these surfaces, and identify the slip surface with the lowest FS. The target FS for static slope stability was considered to be 1.3 because this is a short-term, temporary condition.

Seismic Stability

Seismic slope stability analyses were performed using a procedure consistent with a guidance document prepared by the U.S. Environmental Protection Agency [USEPA, 1995]. The procedure is as follows:

1. Estimate the peak ground acceleration (PGA) at the site.

2. Perform pseudo-static slope stability analyses for the potential critical section to evaluate the yield acceleration. The yield acceleration is the horizontal acceleration at which a marginally stable condition is produced (i.e., factor of safety of 1.0) for the potential slip surface. A trial-and-error process was applied to evaluate the yield acceleration.

3. The yield acceleration (k_y) was compared to the peak horizontal acceleration (a_{max}) of the slide mass due to the design earthquake. If k_y is greater than a_{max}, the analysis is concluded, as Dike 2 will not likely undergo permanent displacement. If k_y is less than a_{max}, then Dike 2 will likely undergo permanent displacement and a displacement analysis is performed to evaluate the magnitude of the permanent displacement.

4. The seismic displacement, corresponding to the computed k_y/a_{max} ratio, is estimated using the results presented by Hynes and Franklin [1984] and the "modified mean + one standard deviation curve" developed by Geosyntec, as presented in Figure 1. The "modified mean + one standard deviation curve" considers data associated with only large earthquakes, and therefore, is more conservative to use. This procedure is consistent with those given in the recent USEPA guidance document [USEPA, 1995]. According to the USEPA guidance document [1995], and based on the recommendations of Seed and Bonaparte [1992], maximum permanent seismic deformations of 6 to 12 inches are typically considered acceptable.

Information Required

Information required for the slope stability analyses included the Dike 2 geometry, subsurface soil stratigraphy, the expected water surface elevation, and the material properties of the soils and dike.

SUBSURFACE STRATIGRAPHY & MATERIAL PROPERTIES

The current site topography in the Dike 2 area was provided by Jacobs based on LIDAR contours dated May 19, 2010 and is shown in Figure 2 [TVA, 2009]. It is noted that the LIDAR contours measure the top surface (i.e., including ponded water) and cannot determine the depth of the pond. Therefore, the elevation at the bottom of the pond and bottom of the Emory River have been assumed to be approximately 740 ft and 741 ft, respectively, based on the design drawings. The elevation of the emergency spillway (i.e., top of Dike 2) is approximately 746 ft. The side slopes of Dike 2 are assumed to be 3 horizontal to 1 vertical (3H:1V), with a top width of approximately 24 ft, based on the design details. A small channel containing the overflow risers is located inside the pond approximately 20 ft from Dike 2 and with a bottom elevation of 736 ft. The side slopes of this channel are assumed to be 2H:1V. The subsurface stratigraphy is assumed to consist of an alluvium clay and silt material, based on the Root Cause Analysis of TVA Kingston Dredge Pond Failure form December 22, 2009 Report [AECOM, 2009]. The material properties used in these analyses are based on the Root Cause Analysis [AECOM, 2009] and past experience with site materials. The material properties are summarized in Table 1 and are the same as previously presented in the 2009 Stability Analyses [Geosyntec, 2009]. It is noted that the design condition is expected to represent a short-term condition due to the storm event and therefore only the undrained case has been considered in these analyses.

A parametric study has been performed for the water table elevation inside the basin. Four different water table elevations (i.e., 744.5 ft, 746 ft, 748 ft and 750 ft) have been considered as part of the parametric study. It is noted that the pond has been assumed to be filled with ash up to the top of the lower overflow riser (i.e., elevation 743.0 ft), as shown in Figure 3. The design water table elevation in the Emory River has been assumed to be the summer high water level elevation of 741 ft.

The seismic stability analysis has been performed based on a peak ground acceleration (PGA) with a 90% or greater probability of non-exceedance in 250 years at the site location. Using the USGS Seismic Hazard Curves and Uniform Response Spectra computer program [Frankel, et. al, 2002], the PGA was calculated to be 0.25g.

ANALYZED CROSS SECTION

The selected Cross Section for analysis passes through the lowest elevation of the emergency spillway as shown on Figure 2. The section geometry and stratigraphy is shown in Figure 4.

RESULTS AND CONCLUSIONS

The calculated minimum FS values for static stability are shown in Table 2. Table 3 summarizes the calculated ground accelerations and permanent deformations under seismic loading. Associated SLIDE output files are included in Attachment 1.

Based on available information and assumptions, the calculation results indicate that Dike 2 is expected to have calculated static FS values greater than the target FS for water elevations of 750 ft and lower. The calculated permanent seismic deformations also satisfy the selected criteria. It is noted that shallow erosion or surface sloughing of the dike may be possible when water flows on the downstream side of the dike (i.e., over the emergency spillway), therefore it is recommended that the dike be inspected for evidence of erosion after large storm events.

REFERENCES

AECOM, *"Root Cause Analysis of TVA Kingston Dredge Pond Failure from December 22, 2008"*, Volume 4, June 12, 2009.

Frankel, A.D., Petersen, M.D., Mueller, C.S., Haller, K.M., Wheeler, R.L., Leyendecker, E.V., Wesson, R.L., Harmsen, S.C., Cramer, C.H., Perkins, D.M., and Rukstales, K.S., "*Documentation for the 2002 Update of the National Seismic Hazard Maps"*, United States Geologic Survey, 2002.

Geosyntec., "*Slope Stability Analyses for Dike 2"*, July 2009.

Hynes, M. and Franklin, A., "*Rationalizing the Seismic Coefficient Method*", Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, Mississippi, Miscellaneous Paper GL-84-14, July 1984.

Rocscience., *"SLIDE — 2-D Limit Equilibrium Slope Stability for Soil and Rock Slopes"*, User's Guide, Rocscience Software Inc., Toronto, Ontario, Canada, 2010.

Seed, R. B., and Bonaparte, R., "Seismic Analysis and Design of Lined Waste Fills: Current Practice," *Proceedings, Stability and Performance of Slopes and Embankments-II, Vol. 2*, ASCE Geotechnical Special Publication No. 31, Berkeley, California, 1992, pp. 1521-1545.

Spencer, E., *"The Thrust Line Criterion in Embankment Stability Analysis"*, Géotechnique, Vol. 23, No. 1, pp. 85-100, 1973.

Tennessee Valley Authority, *"Drawing Set 10W290: Kingston Fossil Plant"*, 2009.

USEPA. RCRA Subtitle D (258) *Seismic Design Guidance for Municipal Solid Waste Landfill Facilities*. Document Number EPA600-R-95-051, 1995.

Tables

Table 1: Material Properties

Material	Unit Weight (pcf)	Shear Strength Properties
Rock Dike	150	c'=0 psf, φ'=45°
Ash	107	c'=100 psf, φ'=0°
Clay and Silt (Foundation Soils)	110	c'=1200 psf, φ'=0°

Note:

These properties are based on data and assumptions previously presented in the 2009 Stability Analyses [Geosyntec, 2009].

Table 2: Summary of Results

Water Elevation (ft)	Description	Static Analysis			Seismic Analysis			
		FS	Target FS	Acceptable?	Yield Acceleration, k_y (g)	k_y/a_{max}	Calculated Deformation (in)	Acceptable?
744.5	Water elevation below emergency spillway	1.61	1.5	Yes	0.15	0.60	1.6	Yes
746	Water elevation at the crest of emergency spillway	1.61	1.5	Yes	0.15	0.60	1.6	Yes
748	Water elevation at approximately half available flow depth in the emergency spillway	1.61	1.5	Yes	0.15	0.60	1.6	Yes
750	Water elevation at the top of the embankment.	1.61	1.5	Yes	0.15	0.60	1.6	Yes

Notes:

1) Water elevation refers to the height of water on the upstream side of Dike 2. The height of water on the downstream side of Dike 2 (i.e., the Emory River) is assumed to be 741 ft.
2) According to the USEPA guidance document [1995], and based on the recommendations of Seed and Bonaparte [1992], maximum permanent seismic deformations of 6 to 12 inches are typically considered acceptable.
3) The associated SLIDE output files are included in Attachment 1.

Figures

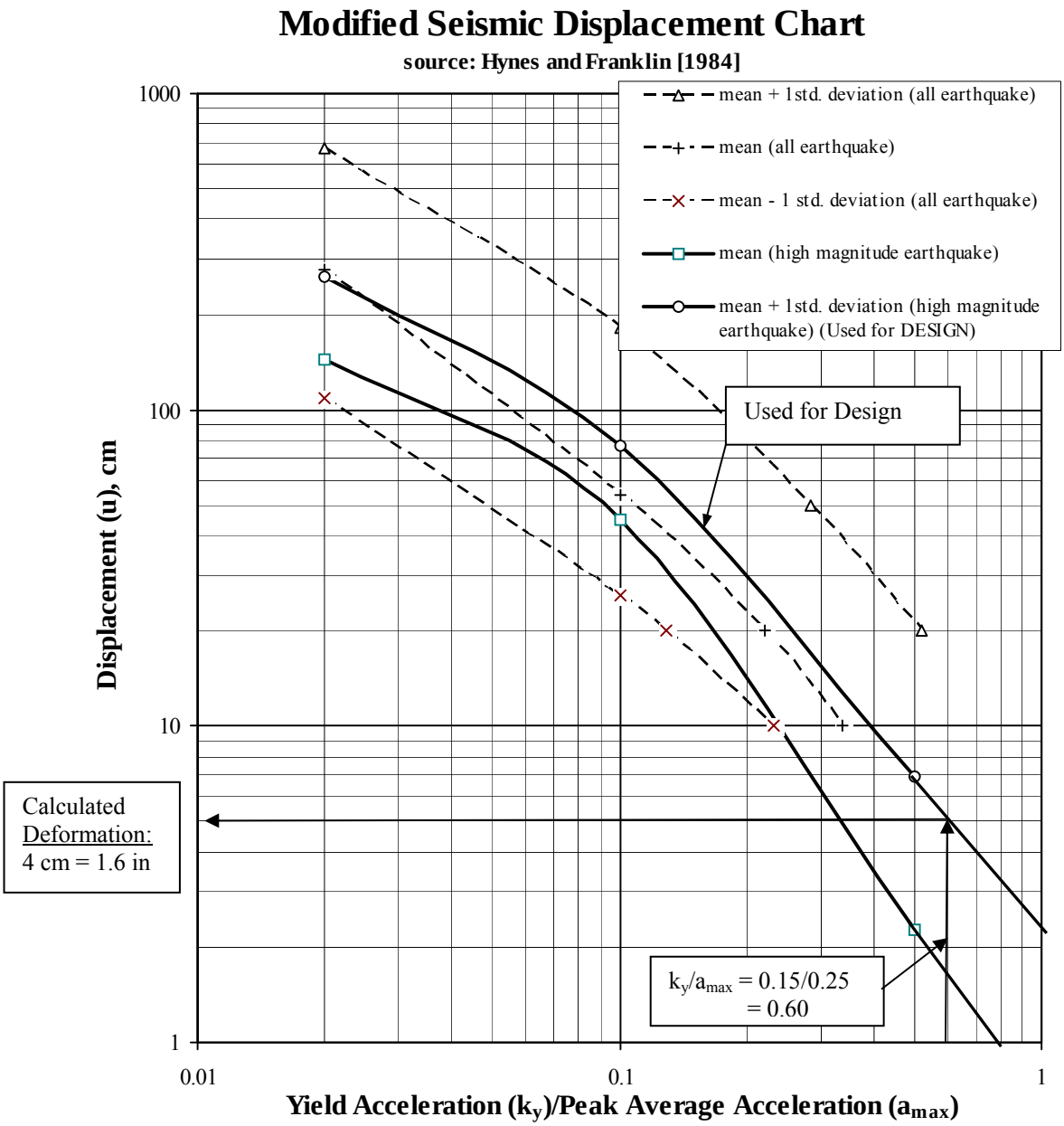


Figure 1. Seismic Deformation Chart [Hynes and Franklin, 1984]

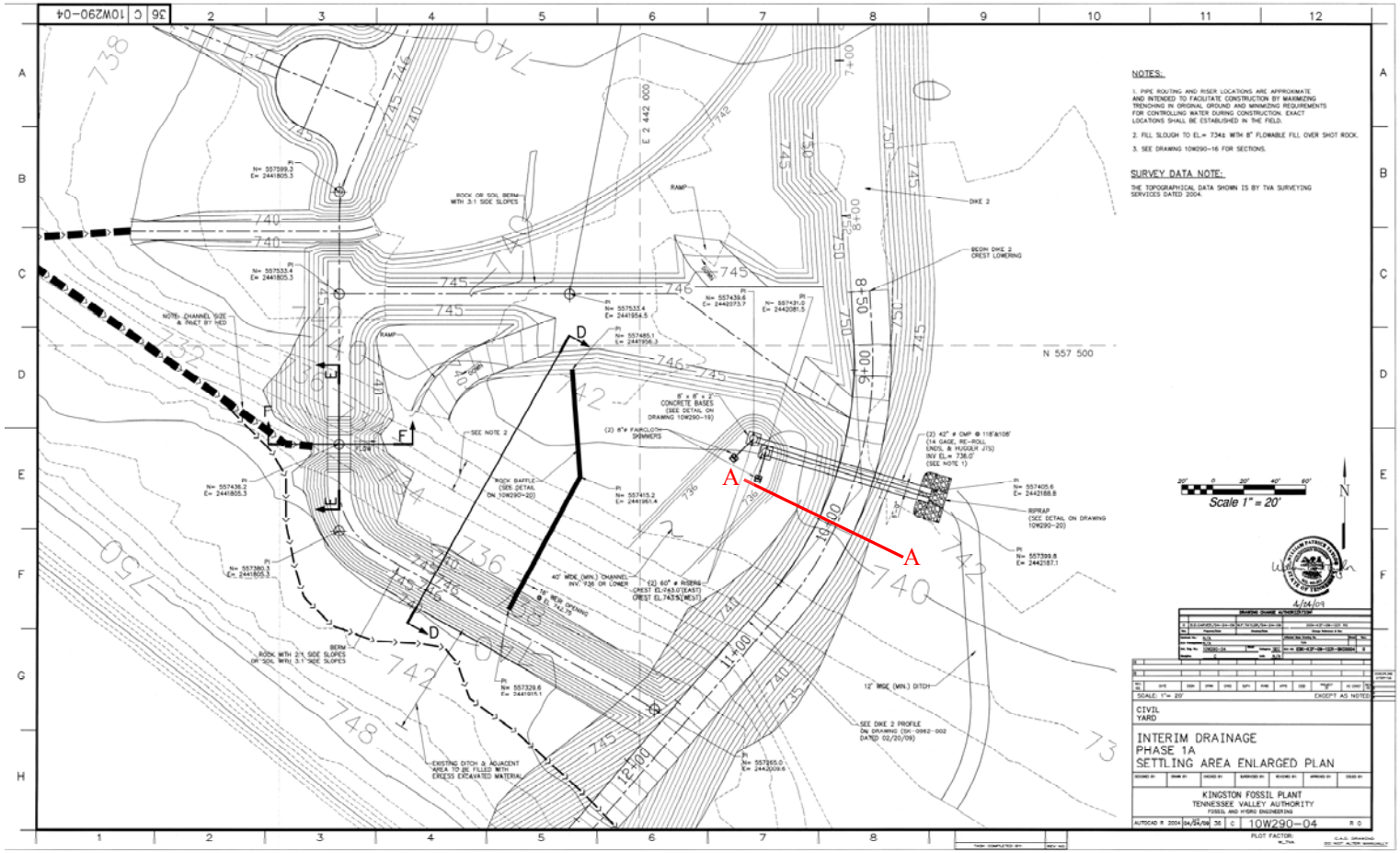


Figure 2. Site Plan near Dike 2 [TVA, 2009]

Note: Cross Section A-A was selected for analysis, as discussed in the package.

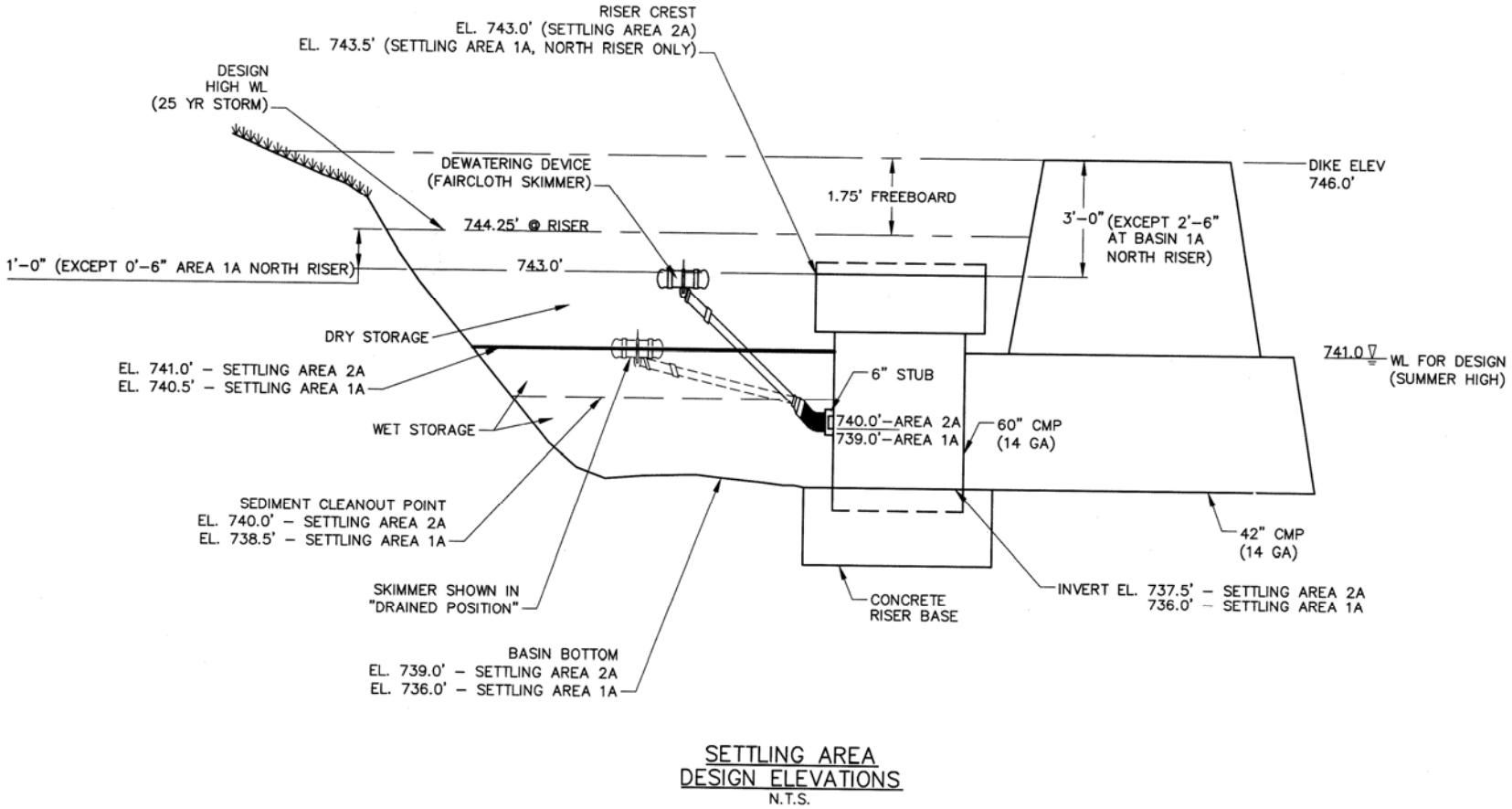


Figure 3. Detail of Overflow Riser [TVA, 2009]

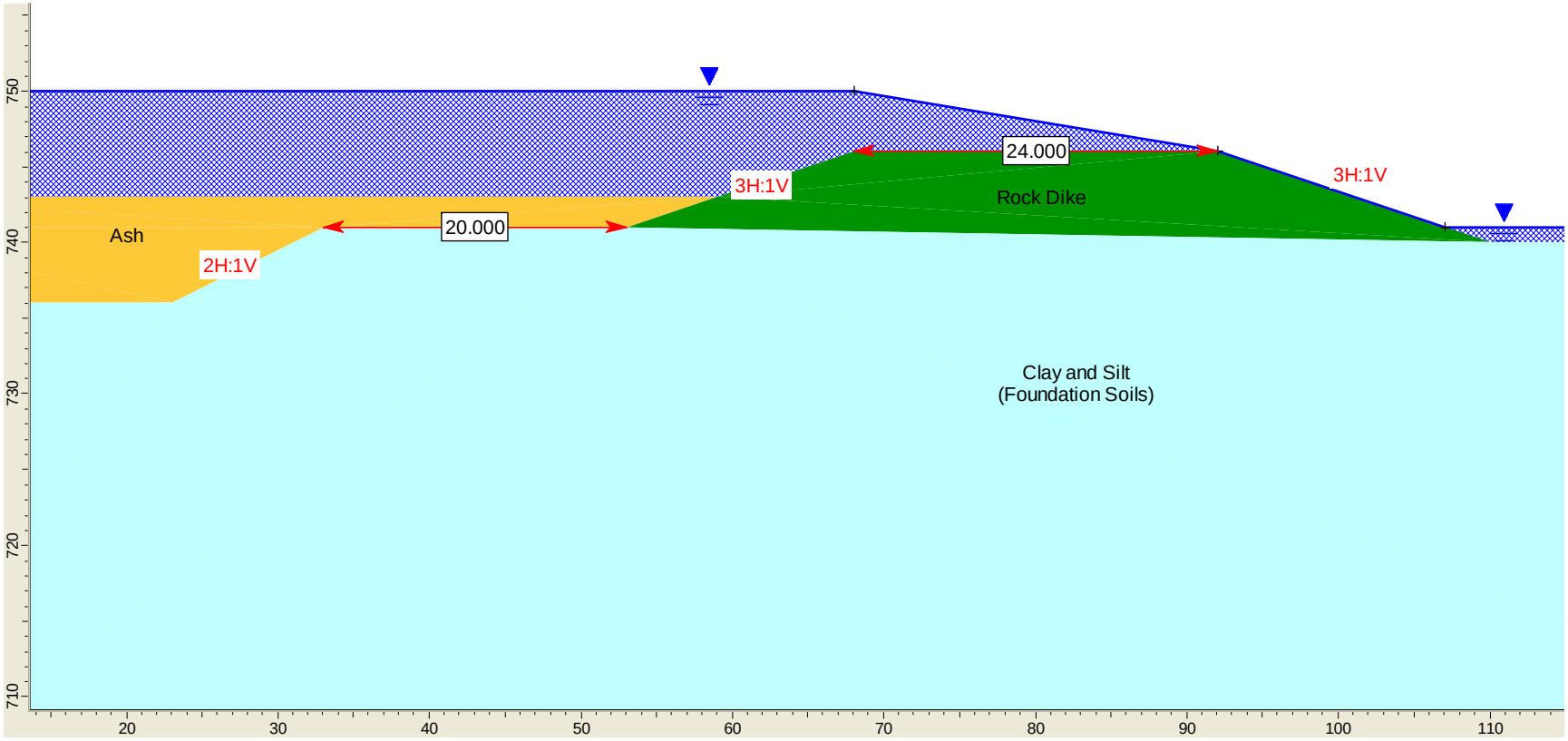


Figure 4. Geometry of Selected Cross Section
Note: This Cross Section is shown as A-A on Figure 2.

Attachment 1:

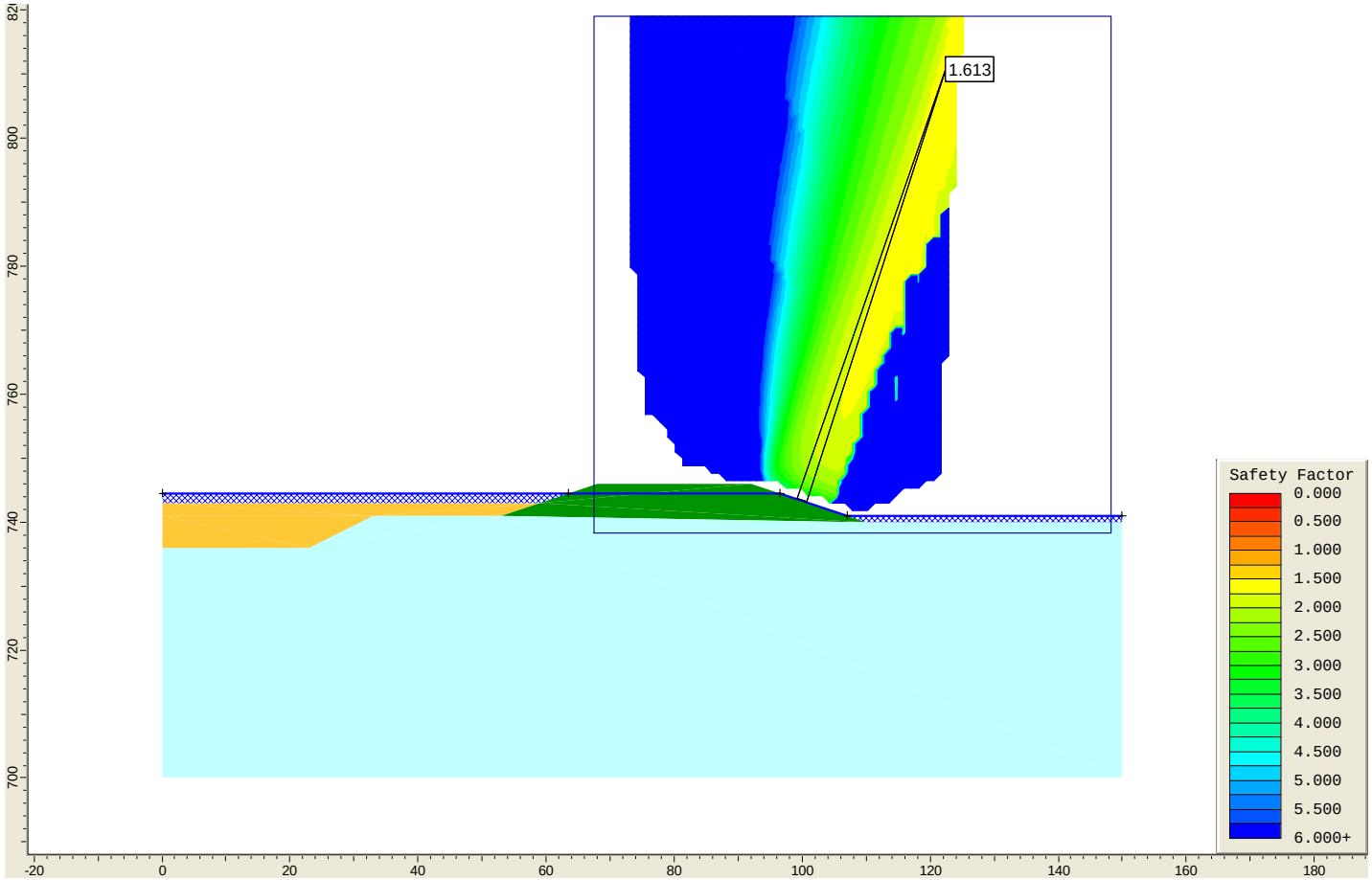
SLIDE Output Files

Notes:

1. The error messages in the output files are a result of invalid slip surfaces generated by the SLIDE program during the automatic search for the most critical slip surface. The invalid slip surfaces do not affect the valid slip surfaces from which the critical slip surface is identified.

Written by: **Joseph Sura** Date: **7/8/2010** Reviewed by: **Ming Zhu** Date: **7/9/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **03**



Static Slope Stability with Water Elevation of 744.5 ft

Slide Analysis Information

Document Name

File Name: Section A_744

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.613400
Center: 122.843, 812.144
Radius: 72.507
Left Slip Surface Endpoint: 99.138, 743.621
Right Slip Surface Endpoint: 100.693, 743.102
Resisting Moment=27.9871 lb-ft
Driving Moment=17.3466 lb-ft
Resisting Horizontal Force=0.366185 lb
Driving Horizontal Force=0.226964 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 25472
Number of Invalid Surfaces: 29979
Error Codes:
Error Code -102 reported for 118 surfaces
Error Code -103 reported for 294 surfaces
Error Code -106 reported for 641 surfaces
Error Code -107 reported for 6322 surfaces
Error Code -108 reported for 11511 surfaces
Error Code -111 reported for 475 surfaces
Error Code -112 reported for 521 surfaces

Error Code -114 reported for 3068 surfaces
Error Code -1000 reported for 7029 surfaces

Error Codes

The following errors were encountered during the computation:

-102 = Two surface / slope intersections, but resulting arc is actually outside soil region.

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.

-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.

-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid

67.466	738.359
148.224	738.359
148.224	819.061
67.466	819.061

Material Boundary

53.000	741.000
110.000	740.000

Material Boundary

0.000	741.000
33.000	741.000
53.000	741.000

Material Boundary

0.000	736.000
23.000	736.000
33.000	741.000

Material Boundary

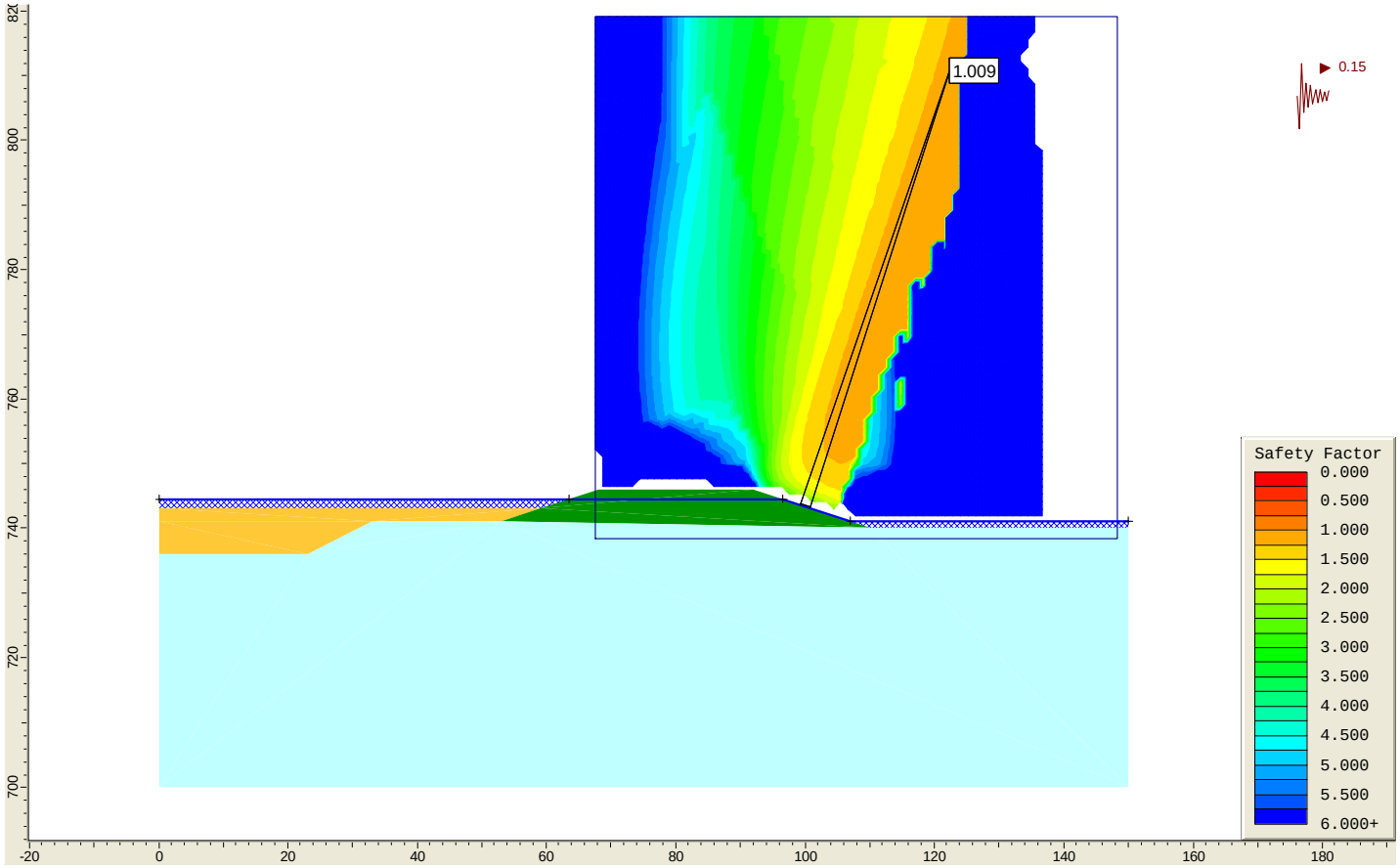
53.000	741.000
59.000	743.000

Water Table

0.000	744.500
63.500	744.500
96.500	744.500
107.000	741.000
150.000	741.000

Written by: **Joseph Sura** Date: **7/8/2010** Reviewed by: **Ming Zhu** Date: **7/9/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **03**



Seismic Slope Stability with Water Elevation of 744.5 ft

Slide Analysis Information

Document Name

File Name: Section A_744_Seismic_FS1

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.15

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.009230
Center: 122.843, 812.144
Radius: 72.507
Left Slip Surface Endpoint: 99.138, 743.621
Right Slip Surface Endpoint: 100.693, 743.102
Resisting Moment=25.3847 lb-ft
Driving Moment=25.1525 lb-ft
Resisting Horizontal Force=0.33214 lb
Driving Horizontal Force=0.329101 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 41085
Number of Invalid Surfaces: 14366
Error Codes:
Error Code -102 reported for 118 surfaces
Error Code -103 reported for 294 surfaces
Error Code -106 reported for 641 surfaces
Error Code -107 reported for 12 surfaces

Error Code -108 reported for 1552 surfaces
Error Code -111 reported for 837 surfaces
Error Code -112 reported for 815 surfaces
Error Code -114 reported for 3068 surfaces
Error Code -1000 reported for 7029 surfaces

Error Codes

The following errors were encountered during the computation:

-102 = Two surface / slope intersections, but resulting arc is actually outside soil region.

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.

-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.

-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid
67.466 738.359
148.224 738.359
148.224 819.061
67.466 819.061

Material Boundary
53.000 741.000
110.000 740.000

Material Boundary
0.000 741.000
33.000 741.000
53.000 741.000

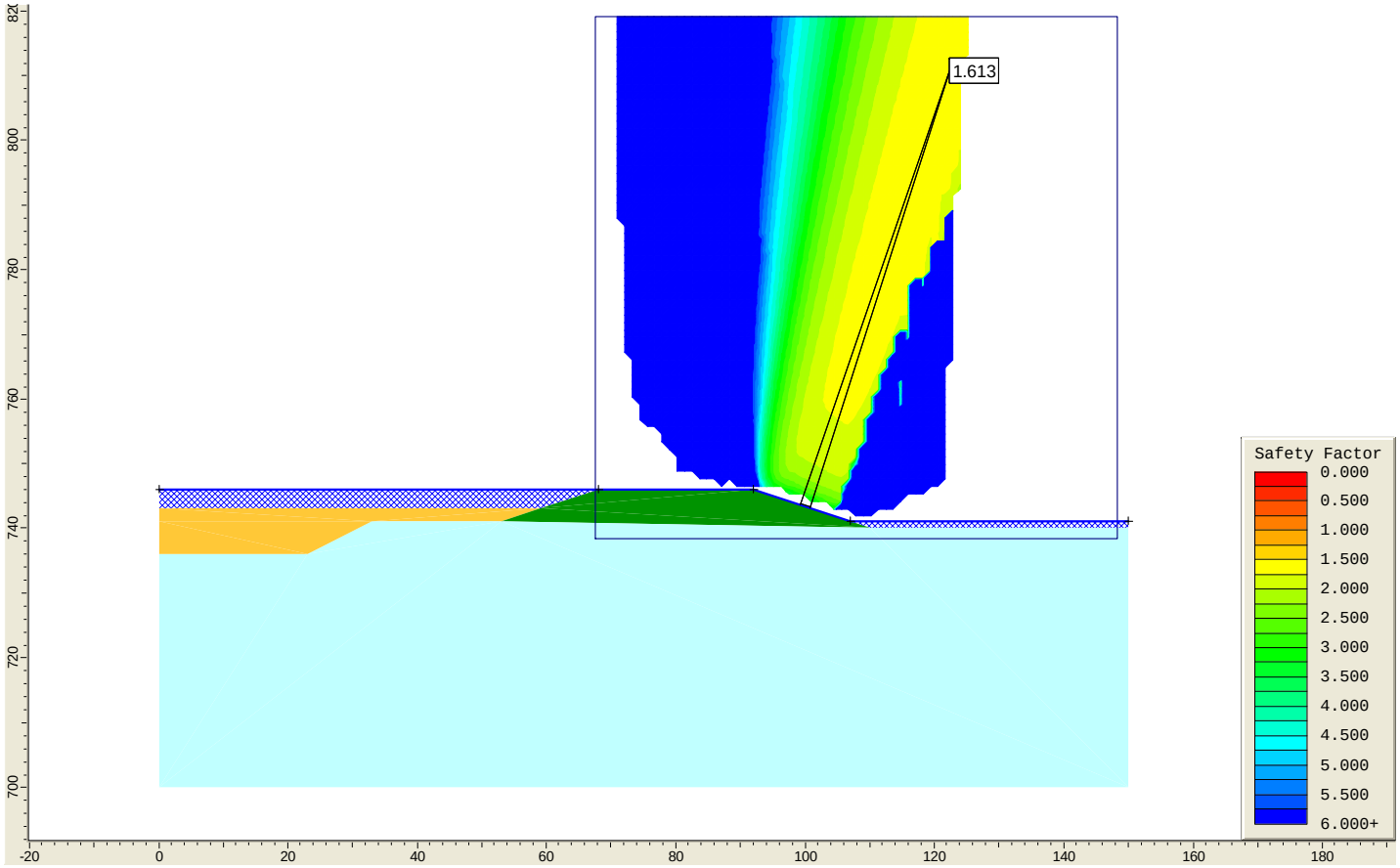
Material Boundary
0.000 736.000
23.000 736.000
33.000 741.000

Material Boundary
53.000 741.000
59.000 743.000

Water Table
0.000 744.500
63.500 744.500
96.500 744.500
107.000 741.000
150.000 741.000

Written by: **Joseph Sura** Date: **7/8/2010** Reviewed by: **Ming Zhu** Date: **7/9/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **03**



Static Slope Stability with Water Elevation of 746 ft

Slide Analysis Information

Document Name

File Name: Section A_746

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.613400
Center: 122.843, 812.144
Radius: 72.507
Left Slip Surface Endpoint: 99.138, 743.621
Right Slip Surface Endpoint: 100.693, 743.102
Resisting Moment=27.9871 lb-ft
Driving Moment=17.3466 lb-ft
Resisting Horizontal Force=0.366185 lb
Driving Horizontal Force=0.226964 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 26342
Number of Invalid Surfaces: 29109
Error Codes:
Error Code -102 reported for 118 surfaces
Error Code -103 reported for 294 surfaces
Error Code -106 reported for 641 surfaces
Error Code -107 reported for 5349 surfaces
Error Code -108 reported for 11566 surfaces
Error Code -111 reported for 486 surfaces
Error Code -112 reported for 558 surfaces
Error Code -114 reported for 3068 surfaces

Error Code -1000 reported for 7029 surfaces

Error Codes

The following errors were encountered during the computation:

-102 = Two surface / slope intersections, but resulting arc is actually outside soil region.

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.

-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.

-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid

67.466	738.359
148.224	738.359
148.224	819.061
67.466	819.061

Material Boundary

53.000	741.000
110.000	740.000

Material Boundary

0.000	741.000
33.000	741.000
53.000	741.000

Material Boundary

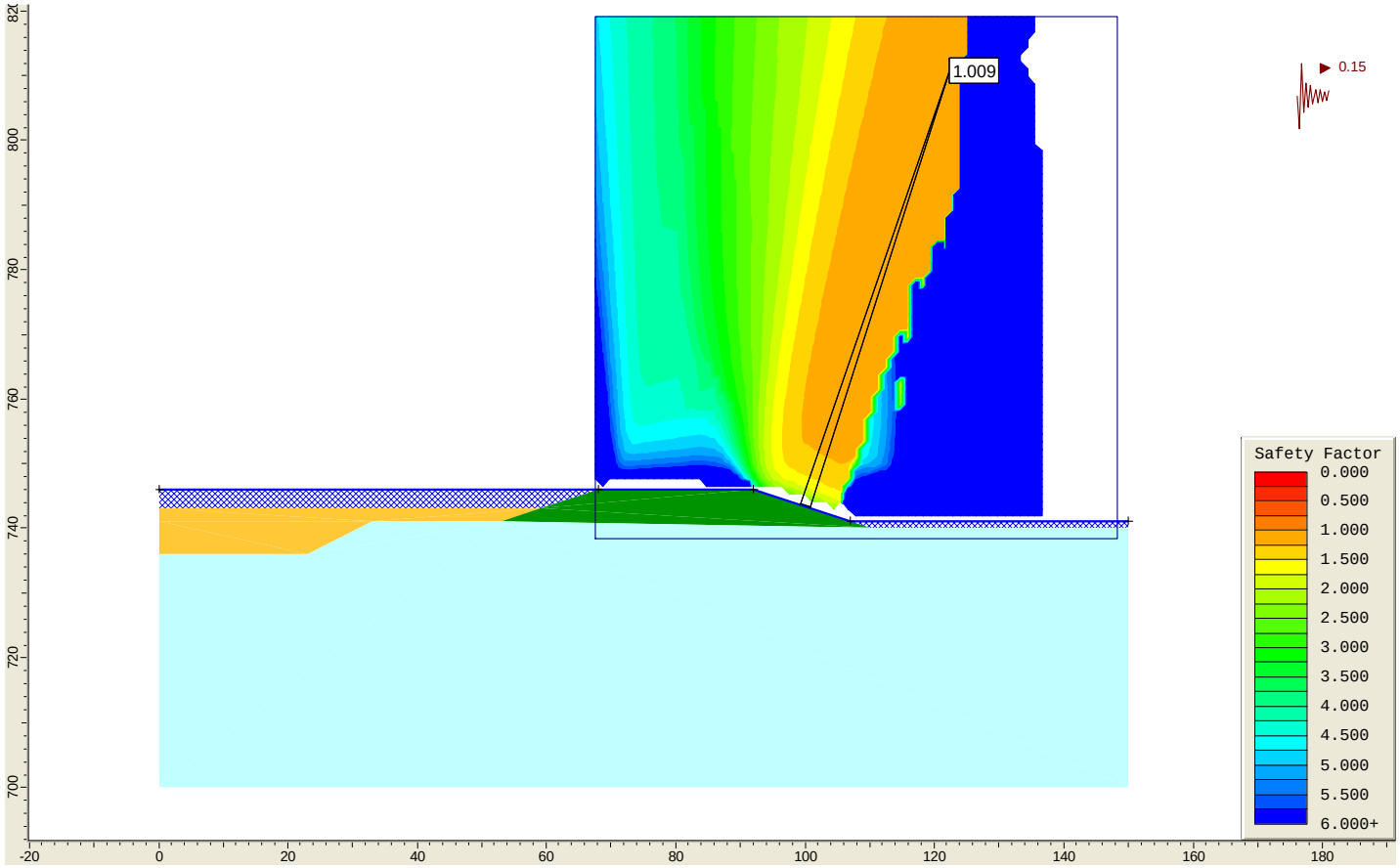
0.000	736.000
23.000	736.000
33.000	741.000

Material Boundary

53.000	741.000
59.000	743.000

Water Table

0.000	746.000
68.000	746.000
92.000	746.000
107.000	741.000
150.000	741.000



Seismic Slope Stability with Water Elevation of 746 ft

Slide Analysis Information

Document Name

File Name: Section A_746_Seismic_FS1

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.15

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.009230
Center: 122.843, 812.144
Radius: 72.507
Left Slip Surface Endpoint: 99.138, 743.621
Right Slip Surface Endpoint: 100.693, 743.102
Resisting Moment=25.3847 lb-ft
Driving Moment=25.1525 lb-ft
Resisting Horizontal Force=0.33214 lb
Driving Horizontal Force=0.329101 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 41392
Number of Invalid Surfaces: 14059
Error Codes:
Error Code -102 reported for 118 surfaces
Error Code -103 reported for 294 surfaces
Error Code -106 reported for 641 surfaces

Error Code -108 reported for 1516 surfaces
Error Code -111 reported for 508 surfaces
Error Code -112 reported for 885 surfaces
Error Code -114 reported for 3068 surfaces
Error Code -1000 reported for 7029 surfaces

Error Codes

The following errors were encountered during the computation:

-102 = Two surface / slope intersections, but resulting arc is actually outside soil region.

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.

-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid

67.466	738.359
148.224	738.359
148.224	819.061
67.466	819.061

Material Boundary

53.000	741.000
110.000	740.000

Material Boundary

0.000	741.000
33.000	741.000
53.000	741.000

Material Boundary

0.000	736.000
23.000	736.000
33.000	741.000

Material Boundary

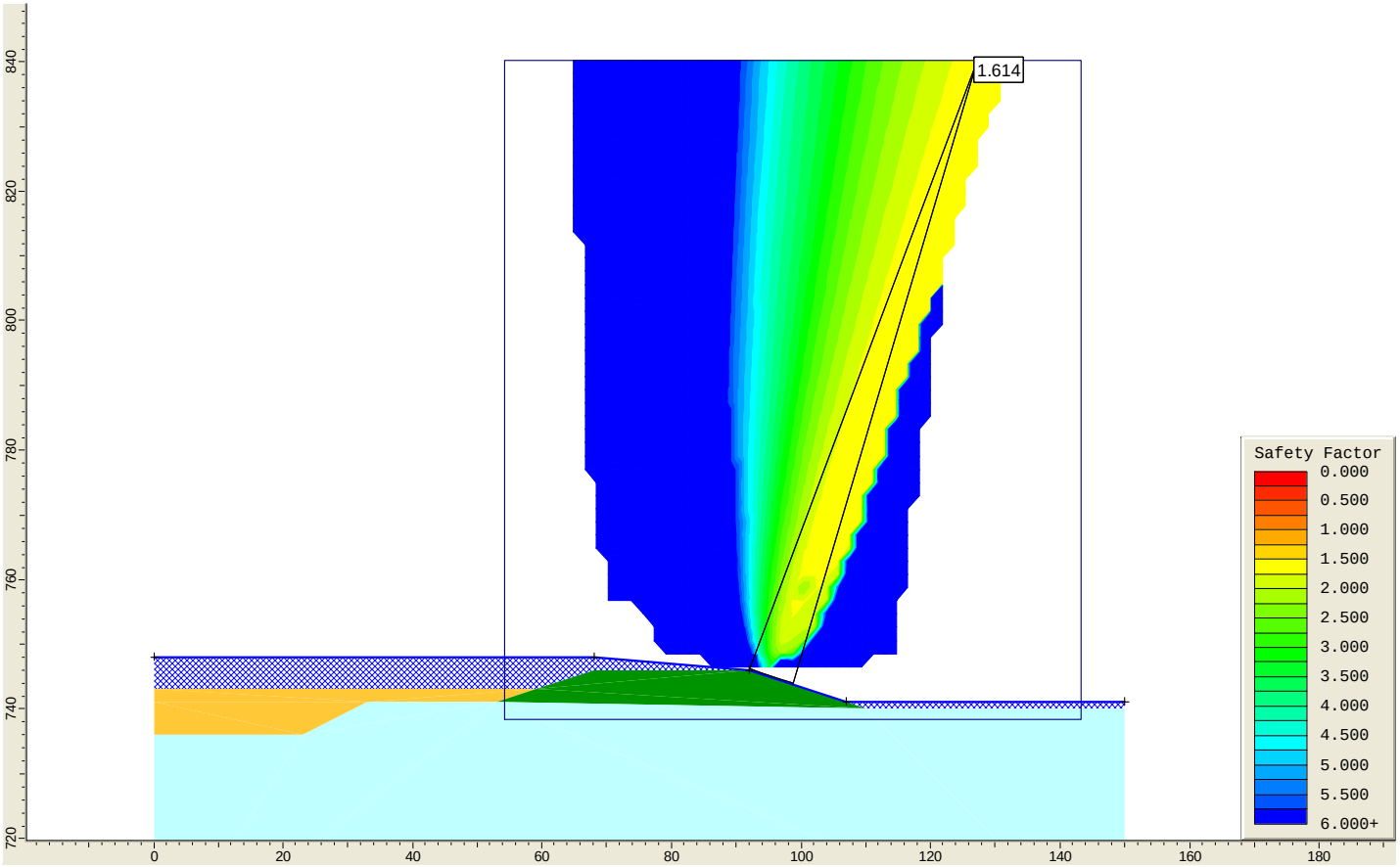
53.000	741.000
59.000	743.000

Water Table

0.000	746.000
68.000	746.000
92.000	746.000
107.000	741.000
150.000	741.000

Written by: **Joseph Sura** Date: **7/8/2010** Reviewed by: **Ming Zhu** Date: **7/9/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **03**



Static Slope Stability with Water Elevation of 748 ft

Slide Analysis Information

Document Name

File Name: Section A_748

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.614190
Center: 127.148, 840.153
Radius: 100.500
Left Slip Surface Endpoint: 92.000, 746.000
Right Slip Surface Endpoint: 98.775, 743.742
Resisting Moment=2320.7 lb-ft
Driving Moment=1437.69 lb-ft
Resisting Horizontal Force=21.9076 lb
Driving Horizontal Force=13.5718 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 14661
Number of Invalid Surfaces: 13950
Error Codes:
Error Code -101 reported for 12 surfaces
Error Code -103 reported for 288 surfaces
Error Code -107 reported for 2328 surfaces
Error Code -108 reported for 472 surfaces
Error Code -111 reported for 246 surfaces
Error Code -112 reported for 278 surfaces
Error Code -114 reported for 943 surfaces
Error Code -1000 reported for 9383 surfaces

Error Codes

The following errors were encountered during the computation:

-101 = Only one (or zero) surface / slope intersections.

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.

-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid

54.198	738.360
143.162	738.360
143.162	840.153
54.198	840.153

Material Boundary

53.000	741.000
110.000	740.000

Material Boundary

0.000	741.000
33.000	741.000
53.000	741.000

Material Boundary

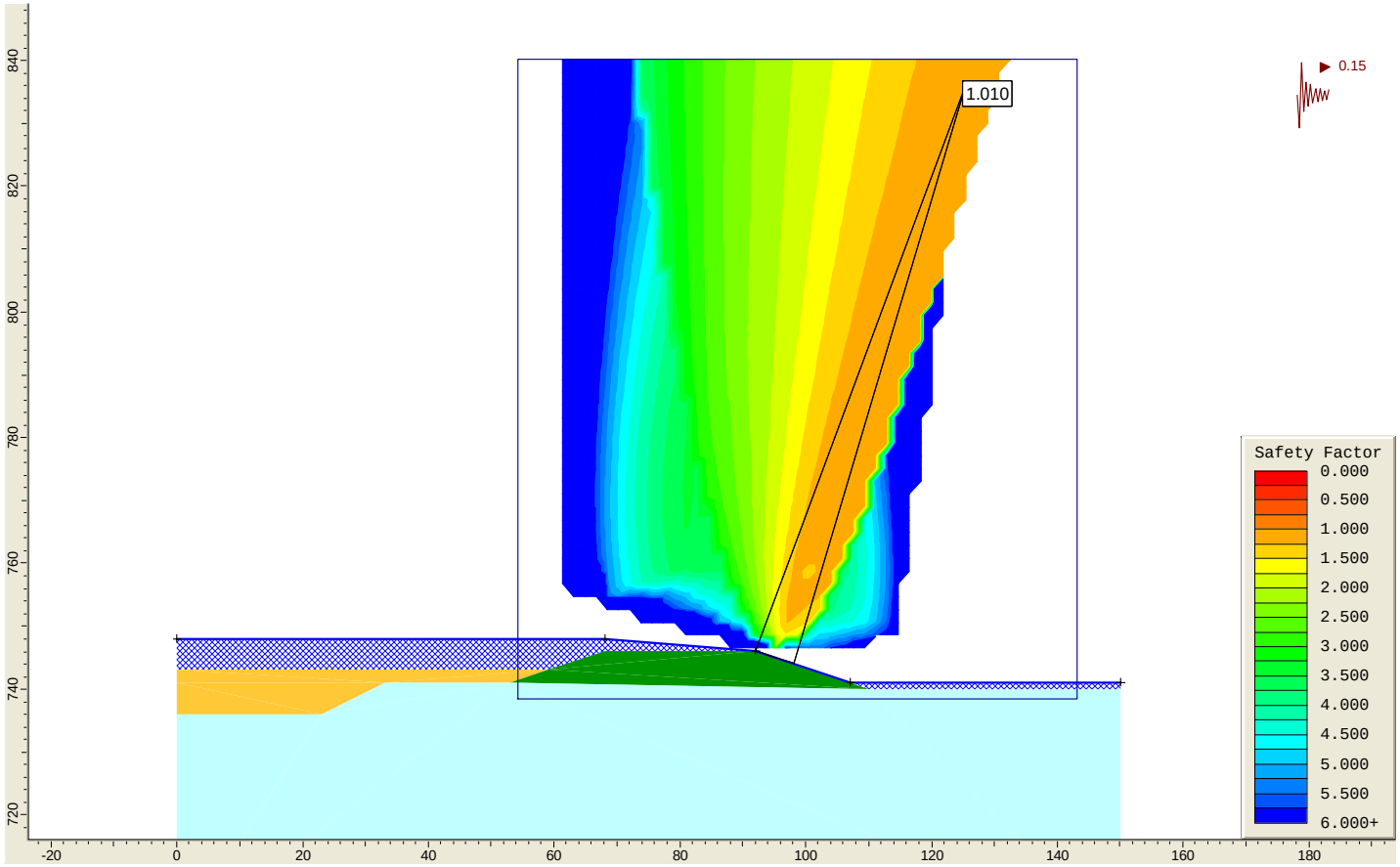
0.000	736.000
23.000	736.000
33.000	741.000

Material Boundary

53.000	741.000
59.000	743.000

Water Table

0.000	748.000
68.000	748.000
92.000	746.000
107.000	741.000
150.000	741.000



Seismic Slope Stability with Water Elevation of 748 ft

Slide Analysis Information

Document Name

File Name: Section A_748_Seismic_FS1

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.15

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.009800
Center: 125.369, 836.081
Radius: 96.067
Left Slip Surface Endpoint: 91.988, 746.000
Right Slip Surface Endpoint: 98.136, 743.955
Left Slope Intercept: 91.988 746.001
Right Slope Intercept: 98.136 743.955
Resisting Moment=1655.85 lb-ft
Driving Moment=1639.79 lb-ft
Resisting Horizontal Force=16.3541 lb
Driving Horizontal Force=16.1954 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 16904
Number of Invalid Surfaces: 11707
Error Codes:
Error Code -101 reported for 12 surfaces
Error Code -103 reported for 288 surfaces

Error Code -108 reported for 217 surfaces
Error Code -111 reported for 176 surfaces
Error Code -112 reported for 688 surfaces
Error Code -114 reported for 943 surfaces
Error Code -1000 reported for 9383 surfaces

Error Codes

The following errors were encountered during the computation:

-101 = Only one (or zero)
surface / slope intersections.

-103 = Two surface / slope intersections,
but one or more surface / nonslope external polygon
intersections lie between them. This usually occurs
when the slip surface extends past the bottom of the
soil region, but may also occur on a benched
slope model with two sets of Slope Limits.

-108 = Total driving moment
or total driving force < 0.1. This is to
limit the calculation of extremely high safety
factors if the driving force is very small
(0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F)
< 0.2 for the final iteration of the safety factor calculation. This screens out
some slip surfaces which may not be valid in the context of the analysis, in
particular, deep seated slip surfaces with many high negative base angle
slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated
at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid

54.198	738.360
143.162	738.360
143.162	840.153
54.198	840.153

Material Boundary

53.000	741.000
110.000	740.000

Material Boundary

0.000	741.000
33.000	741.000
53.000	741.000

Material Boundary

0.000	736.000
23.000	736.000
33.000	741.000

Material Boundary

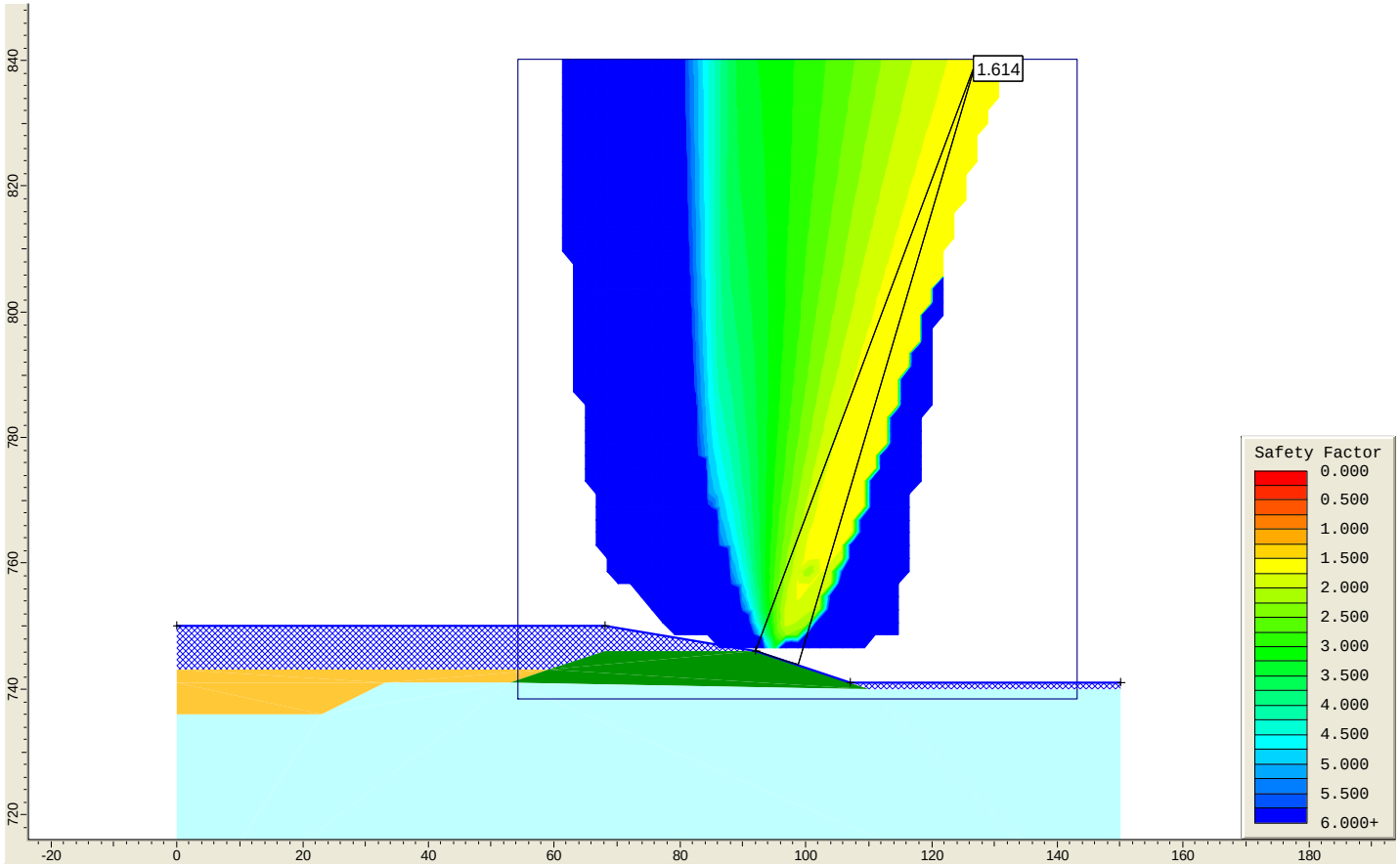
53.000	741.000
59.000	743.000

Water Table

0.000	748.000
68.000	748.000
92.000	746.000
107.000	741.000
150.000	741.000

Written by: **Joseph Sura** Date: **7/8/2010** Reviewed by: **Ming Zhu** Date: **7/9/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **03**



Static Slope Stability with Water Elevation of 750 ft

Slide Analysis Information

Document Name

File Name: Section A_750

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.614200
Center: 127.148, 840.153
Radius: 100.500
Left Slip Surface Endpoint: 92.000, 746.000
Right Slip Surface Endpoint: 98.775, 743.742
Resisting Moment=2320.71 lb-ft
Driving Moment=1437.69 lb-ft
Resisting Horizontal Force=21.9076 lb
Driving Horizontal Force=13.5718 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 15959
Number of Invalid Surfaces: 12652
Error Codes:
Error Code -101 reported for 12 surfaces
Error Code -103 reported for 288 surfaces
Error Code -107 reported for 788 surfaces
Error Code -108 reported for 635 surfaces
Error Code -111 reported for 264 surfaces
Error Code -112 reported for 339 surfaces
Error Code -114 reported for 943 surfaces
Error Code -1000 reported for 9383 surfaces

Error Codes

The following errors were encountered during the computation:

-101 = Only one (or zero) surface / slope intersections.

-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.

-107 = Total driving moment or total driving force is negative. This will occur if the wrong failure direction is specified, or if high external or anchor loads are applied against the failure direction.

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid

54.198	738.360
143.162	738.360
143.162	840.153
54.198	840.153

Material Boundary

53.000	741.000
110.000	740.000

Material Boundary

0.000	741.000
33.000	741.000
53.000	741.000

Material Boundary

0.000	736.000
23.000	736.000
33.000	741.000

Material Boundary

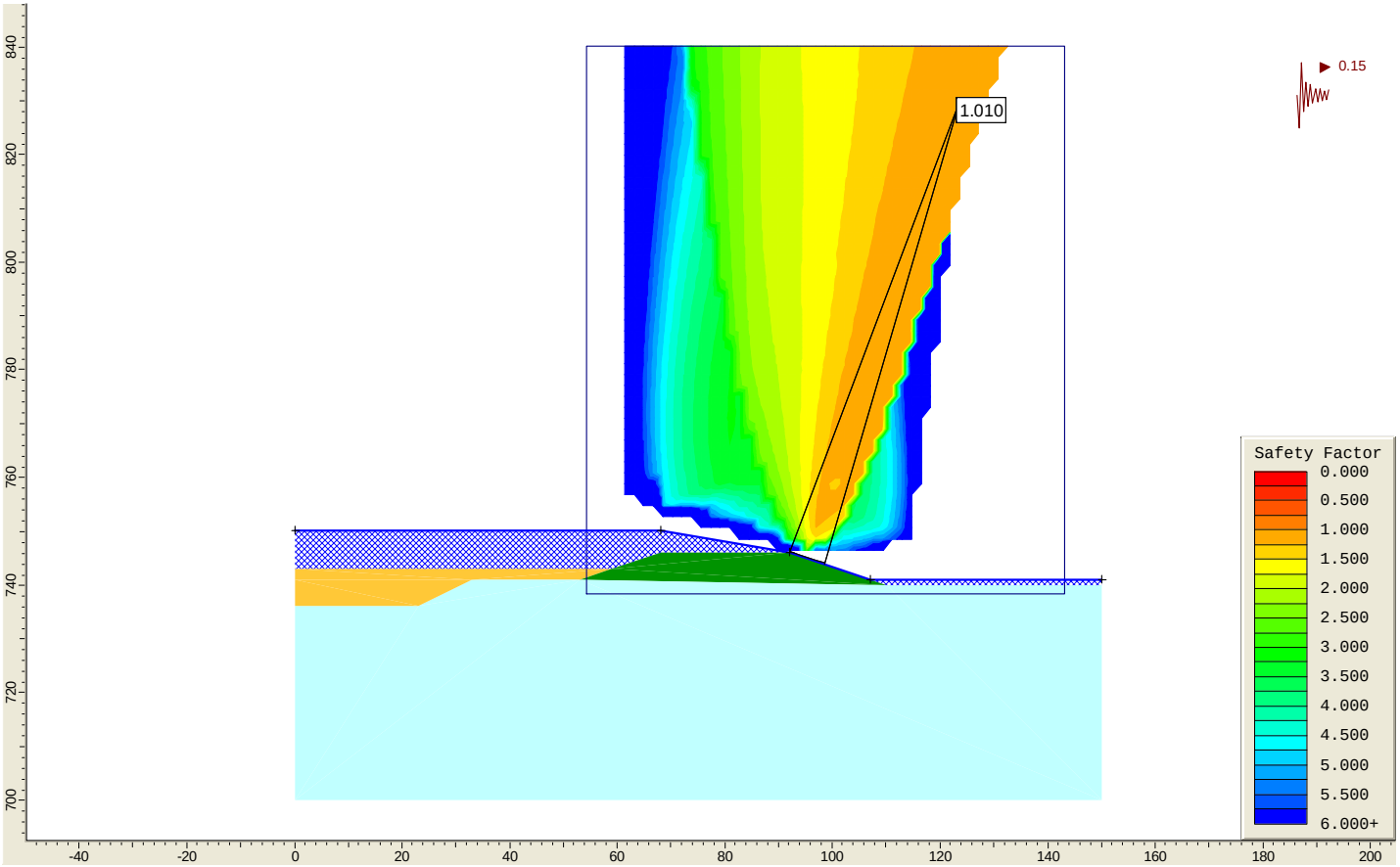
53.000	741.000
59.000	743.000

Water Table

0.000	750.000
68.000	750.000
92.000	746.000
107.000	741.000
150.000	741.000

Written by: **Joseph Sura** Date: **7/8/2010** Reviewed by: **Ming Zhu** Date: **7/9/2010**

Client: **TVA** Project: **Integrity Evaluation of Dike 2** Project/ Proposal No.: **GK4693** Task No.: **03**



Seismic Slope Stability with Water Elevation of 750 ft

Slide Analysis Information

Document Name

File Name: Section A_750_Seismic_FS1

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Groundwater Method: Water Surfaces
Data Output: Standard
Calculate Excess Pore Pressure: Off
Allow Ru with Water Surfaces or Grids: Off
Random Numbers: Pseudo-random Seed
Random Number Seed: 10116
Random Number Generation Method: Park and Miller v.3

Analysis Methods

Analysis Methods used:
Spencer

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Search Method: Grid Search
Radius increment: 10
Composite Surfaces: Disabled
Reverse Curvature: Invalid Surfaces
Minimum Elevation: Not Defined
Minimum Depth: Not Defined

Loading

Seismic Load Coefficient (Horizontal): 0.15

Material Properties

Material: Rock Dike
Strength Type: Mohr-Coulomb
Unit Weight: 150 lb/ft3
Cohesion: 0 psf
Friction Angle: 45 degrees
Water Surface: Water Table
Custom Hu value: 1

Material: Ash (UD)
Strength Type: Undrained
Unit Weight: 107 lb/ft3
Cohesion Type: Constant
Cohesion: 100 psf
Water Surface: None

Material: Clay and Silt (UD)
Strength Type: Undrained
Unit Weight: 110 lb/ft3
Cohesion Type: Constant
Cohesion: 1200 psf
Water Surface: None

Global Minimums

Method: spencer
FS: 1.009810
Center: 123.590, 829.974
Radius: 89.719
Left Slip Surface Endpoint: 92.000, 746.000
Right Slip Surface Endpoint: 98.478, 743.841
Resisting Moment=1839.5 lb-ft
Driving Moment=1821.63 lb-ft
Resisting Horizontal Force=19.4547 lb
Driving Horizontal Force=19.2657 lb

Valid / Invalid Surfaces

Method: spencer
Number of Valid Surfaces: 16861
Number of Invalid Surfaces: 11750
Error Codes:
Error Code -101 reported for 12 surfaces
Error Code -103 reported for 288 surfaces
Error Code -108 reported for 217 surfaces
Error Code -111 reported for 171 surfaces

Error Code -112 reported for 736 surfaces
Error Code -114 reported for 943 surfaces
Error Code -1000 reported for 9383 surfaces

Error Codes

The following errors were encountered during the computation:

-101 = Only one (or zero)
surface / slope intersections.

-103 = Two surface / slope intersections,
but one or more surface / nonslope external polygon
intersections lie between them. This usually occurs
when the slip surface extends past the bottom of the
soil region, but may also occur on a benched
slope model with two sets of Slope Limits.

-108 = Total driving moment
or total driving force < 0.1. This is to
limit the calculation of extremely high safety
factors if the driving force is very small
(0.1 is an arbitrary number).

-111 = safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F)
< 0.2 for the final iteration of the safety factor calculation. This screens out
some slip surfaces which may not be valid in the context of the analysis, in
particular, deep seated slip surfaces with many high negative base angle
slices in the passive zone.

-114 = Surface with Reverse Curvature.

-1000 = No valid slip surfaces are generated
at a grid center. Unable to draw a surface.

List of All Coordinates

Search Grid
54.198 738.360
143.162 738.360
143.162 840.153
54.198 840.153

Material Boundary
53.000 741.000
110.000 740.000

Material Boundary
0.000 741.000
33.000 741.000
53.000 741.000

Material Boundary
0.000 736.000
23.000 736.000
33.000 741.000

Material Boundary
53.000 741.000
59.000 743.000

Water Table
0.000 750.000
68.000 750.000
92.000 746.000
107.000 741.000
150.000 741.000